JOURNAL

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OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

VOL. CXXIX. APRIL, 1890. NO. 4

THE FRANKLIN INSTITUTE is not responsible for the statements and opinions advanced by contributors to the JOURNAL.

ELECTRIC RAILWAYS.

BY EUGENE GRIFFIN.

[*A Lecture delivered before the* FRANKLIN INSTITUTE, *February 10, 1890.*]

The Speaker was introduced by Prof. EDWIN J. HOUSTON, of the INSTITUTE, and spoke as follows:

MEMBERS OF THE INSTITUTE, LADIES AND GENTLEMEN:

Street railways are the arteries of our great cities; the suburbs and parks are the lungs; the business centre is the heart. The arteries radiate from the heart with numerous and winding ramifications through the entire system. The blood is purified and rejuvenated through the lungs. The ebb and flow of traffic is an exact indication of the healthy condition of the city as the ebb and flow of the blood is of the body. Choke an artery and stagnation results. Cut it off entirely and the part no longer supplied mortifies and

ing the membership, and urged the Special Committee charged with this work not to intermit its activity. Mr. H. R. HEYL, Chairman of the Special Committee to Increase Membership, gave a brief statement of its work, and appealed for personal co-operation on the part of all the members. Mr. S. L. WIEGAND also made some remarks on the subject.

The President presented an oral report of the progress of the work of the Reorganization Committee, and read a list of the subscriptions to the Building Fund that have thus far been received. These amounted to about $36,000.

The Secretary reported the resignations of Mr. JOHN HAUG, Mr. ADDISON HUTTON and Mr. GEORGE H. PERKINS from the Committee on Science and the Arts. An election to fill the vacancies was thereupon held, which resulted in the choice of—

Prof. WILLIAM D. MARKS for the unexpired term of Mr. HAUG.

Mr. T. CARPENTER SMITH for the unexpired term of Mr. HUTTON.

Dr. CHARLES M. CRESSON for the unexpired term of Mr. PERKINS.

Mr. ALFRED SHEDLOCK, Secretary of the Industrial Light Company of New York, read a paper on the system and apparatus for illumination called *Lucigen*. The new light is intended to be used in large areas, such as foundries, erecting shops, etc., on docks, wharves; in railway, bridge and other repair work or construction, and generally for industrial and engineering work requiring to be carried on at night in large areas or in the open, and where a powerful illumination is called for. For all such forms of service, *Lucigen* is claimed to be specially adapted, being capable of yielding any desired intensity of light, while the large volume of flame which characterizes it relieves the light from certain serious objections that have been found to exist with the electric arc light.

Mr. SHEDLOCK'S paper was illustrated by throwing on the screen a series of views showing the construction and mode of operation of the apparatus, and by the exhibition of several forms of *Lucigen*, which were shown in operation. The paper has been referred for publication.

Mr. S. LLOYD WIEGAND gave an oral description of the Richards Ruling Machine, for engravers' use, illustrating his remarks by the exhibition of the machine, and by the presentation on the screen of pictures showing its mechanical construction, and specimens of its work.

Mr. G. M. ELDRIDGE followed with an account of the improvement in spinning mules invented by Mr. JAMES LOWE, which was described and illustrated in the same manner.

The Secretary, in his report on current matters of technical interest, exhibited a card of samples of seamless tubing made from various metals by a new process devised by Mr. ELLWOOD IVINS. Several of these specimens are remarkable on account of their extremely small diameter and extremely thin walls. The process of Mr. IVINS permits the making of seamless (solderless) tubes, not only in brass, copper, tin, zinc, aluminium, etc., but also in steel, of any desired diameter, down even to the $\frac{1}{100}$th of an inch.

Adjourned.

WM. H. WAHL, *Secretary*.

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dies. A new artery, reaching to a new part, means new life and new growth.

The simile is not exaggerated. Few appreciate the vital part played by our street railway transportation system in the daily routine of our great cities. Such a forcible lesson as the New York strike of 1888 awakens temporary reflection, but is soon forgotten. Street cars are so common that we avail ourselves of the benefits they confer without consideration of the means by which these benefits are made available. The study of statistics, however, discloses many facts that are interesting, instructive and astonishing, as to the dependence of the public upon street cars, and the close connection between their efficient service and the wealth, health, growth and comfort of the city.

Many of you are probably not aware of the fact that the cars of Philadelphia alone carry nearly fifty million more passengers per year than all the steam roads of the great state of Pennsylvania. A few statistics of this nature are more impressive than pages of rhetoric.

During the year ending September 30, 1888, the 108 street railways in the state of New York carried 554,266,682 passengers, or 100 times the total population. If the ratio was even approximately the same in other states, there must have been carried by the street railways of the United States, during that year, not less than four billion passengers.

In New York City, the surface and elevated roads carried 371,021,524 passengers, or 247 times the population. In 1855, with a population of 620,810, New York City furnished 18,488,459 passengers, only twenty-nine times the population. The gain in ratio of passengers to population has been uniform from 1855 to 1888, being forty-five in 1860; 122 in 1870; 175 in 1880; 225 in 1885; and 247 in 1888.

The same increase is noticeable in other cities. The population of Boston in 1870 was 250,256. The street railways, with 346 cars, carried 23,176,167 passengers. In 1888, with 1,584 cars, the roads carried 97,039,919 passengers. The ratio of passengers to population increased in eighteen years from ninety-three to 215, and the ratio of passengers to cars diminished from 64,090 to 61,262.

The Philadelphia roads carried 143,443,959 passengers in 1888, or 137 times the population.

In Massachusetts, the street railways carried fifty per cent. more passengers than the steam roads. In Pennsylvania, the ratio was 2 to 1. In New York State 5¼ to 1. These figures lead to several important conclusions:

(1) Our street railways carry approximately twice as many passengers as the steam roads.

(2) The number of passengers increases much faster than the population, which means that more people ride, and ride more frequently each year.

The transportation of upwards of four billion passengers yearly with safety, speed, comfort and economy, is a gigantic task, and the means by which it is accomplished are well worthy of careful investigation. There is perhaps no line of work for the inventor and the engineer in which improvements are of more direct benefit to the masses than street-car propulsion.

At present we have five well-known methods of municipal transit; horse cars, cable cars, steam dummies, elevated roads with steam locomotives, and electric roads. Each is valuable in its way and each has been of great utility to the public at large. There are many well-known objections to the first four methods, which it is believed electricity will obviate.

The electric railway, as usually constructed, may be briefly described as consisting of a power station, where the dynamos generate electricity, which is carried by an overhead wire out over the tracks, thence by means of the trolley arm on top of each car down through the motors under the car, through the wheels, and so to the rails, and back through the rails to the dynamos at the power station thus completing the circuit. The electric current causes the motor armatures to revolve, and the armatures, being geared to the car axles, move the car. The driver stops the car by breaking the electric circuit, and reverses by reversing the direction of the current through the motors.

I have no intention of entering into any detailed history of the development of the electric motor and its application

to street-car propulsion. There are, however, a few epochs in this development which it may be of interest to note.

In 1834, Jacobi, a Russian physicist, produced rotary motion by means of an electro-magnet. In July of the same year, Thomas Davenport, a blacksmith, of Brandon, Vt., completed and exhibited an electric motor.

In 1851, Prof. Page, of the Smithsonian Institute, made a trial trip with an electro-magnetic locomotive on the Baltimore and Ohio Railroad from Washington to Bladensburg.

In 1864, Pacinotti first announced the principle of the reversibility of the electric dynamo.

In 1873, the Gramme Company made a practical demonstration of this principle at the Vienna Exhibition. Since this date, electric railways have been among the possibilities; before this, the cost of zinc as a fuel made them impracticable.

In 1879, Dr. Werner Siemens constructed and operated an exhibition railway at the Industrial Exhibition at Berlin. A third rail centrally placed between the other two was used as the outgoing conductor.

In 1881, the first commercial railway was put in operation in the suburbs of Berlin—the Lichterfelde Line. It is a mile and a half long with a gauge of three feet three inches. The rails are laid on insulated sleepers, one used for the outgoing and one for the return circuit. This method of construction puts it without the pale of practicability for ordinary tram-car work.

In the same year, 1881, the first overhead line was built. This was an experimental road at the Paris Electrical Exhibition. The conductors were suspended hollow tubes with longitudinal slits. Contact was obtained by metallic bolts drawn through the tubes by wires attached to the cars.

In February, 1883, the Van Depoele system was exhibited on a short road in Chicago. The use of an overhead wire was contemplated, but the ground being frozen the wire was strung beneath the cars and kept from the ground by boards with V-shaped tops placed at frequent intervals. The

rails were used for the return current. This exhibition plant was run every day for several weeks with complete success, carrying crowds of people.

In November, 1883, the celebrated Portrush Railway in the North of Ireland was put in operation. On this road, the conductor is an insulated rail placed on uprights alongside the track.

In November, 1883, the Daft Motor "Ampère" was tried experimentally on the Mt. McGregor and Lake George Railroad at Saratoga Springs.

In 1884, the Bentley-Knight conduit system was tested on the East Cleveland Road, at Cleveland, O., and the Van Depoele conduit system at the Toronto Exhibition.

In 1885, the road at Blackpool, England, was formally opened. This is operated by the conduit system.

Storage battery cars were exhibited as early as 1881 at the Paris Exposition. In 1882, a line was put in operation at Breuil-en-Auge, France, using Faure batteries. Storage cars have also been tried at Brussells and other places abroad. The only road actually operating storage batteries in this country, is the Fourth Avenue Line, New York City. This road has had as many as ten cars in service. At present but one is running.

In the summer of 1886, the Sprague Company began the installation of the Richmond Road. This road was in full operation in the spring of 1887. On July 4th of the same year (1887), the first Thomson-Houston car was started on the line at Crescent Beach, Mass.

ELECTRIC RAILWAYS IN THE UNITED STATES AND CANADA.

	1885	1886	1887	1888	1889	JANUARY 1, 1890.		
						Total in operation and under contract.	Total in operation.	Total under contract.
Number of electric railways put in operation each year,	3	5	7	33	104	251	137	114
Number of miles of road, . .	7·5	28	29	130·5	641	1641·75	771·5	870·25
Number of cars, ...	13	39	81	265	965	2346	1230	1116

The development of electric railways in this country is shown by the foregoing statistics:

January 1, 1890, shows an average of about six miles and nine cars for each road.

Considering the electric road from a scientific standpoint, we note:

(1) The generating station.
(2) The car equipment.
(3) The line.
(4) Storage batteries.

THE GENERATING STATION.

Location.—One of the great advantages of electricity as a motive-power is the possibility and practicability of placing the power station in the most convenient location. If by going several miles into the country, we can secure cheap water-power, we do so, as the loss in transmission is inconsiderable—nothing in comparison with the possible reduction in first cost. Or we can go to the water-side where compound condensing engines can be used, cutting down the coal consumption to two pounds of coal per horse-power-hour, or even less. Or we can go to the side of the railroad track where coal can be delivered without cartage at the lowest possible cost. We may combine many of these advantages and we are free to seek them all.

Power Plant.—To determine the best form of wheel with water-power, or steam plant with coal, are engineering problems which many are ready and able to solve. We must recognize the fact, however, that street-car work imposes a very variable load on the engines and dynamos and the fluctuations are sudden and violent. We require stronger engines than are needed for constant loads.

Dynamo.—The ordinary form of incandescent dynamo is used. The latest type of machine developed by the Thomson-Houston Company is a 100 horse-power four-pole compound-wound dynamo. This machine shows an electrical efficiency of over ninety-five per cent. The perfection of the regulation of the series coils is practically shown in an eighty horse-power machine at the electric-lighting station

at Lynn, Mass. A single motor car on the Highland Circuit Line is run from this dynamo. The circuit is about 1·7 miles long with eleven curves and grades ranging up to ten, twelve, thirteen and fourteen per cent. One grade, 750 feet long, averages thirteen per cent. with a short stretch of fourteen per cent. near the middle. The car usually descends this grade, but has a long grade of ten per cent. to ascend. To test the power of the motors it is a common occurrence to stop the car, even when heavily loaded, on the steepest grade, and then reverse the motors and back up the hill. It has been noted that with a full load on the car an instantaneous effort of about eighty horse-power at the station has been required to start the car back up the fourteen per cent. grade. The sudden change of load from 0 to 80 horse-power probably imposes as severe conditions upon this generator as upon any in use in this or any other country. The generator was carefully tested while the car was making two or three round trips, and the greatest fluctuation observed was two volts. One is unable to distinguish any difference in the action of the dynamo when the load is on and when running free. The engine, however, speaks forcibly at times.

The rapid development of railway work calls for larger stations and larger generators. The Thomson-Houston Company is now building 250 horse-power machines of the same four-pole type as the 100 horse-power. It is probable that even larger machines will be required in the near future. Carbon brushes are used with these generators, having many advantages over copper. The wear on the commutator is reduced to a minimum of trifling consideration and the surface is kept smooth and polished. The use of carbon brushes and the perfection of the compounding are of vital importance where machines are subjected to the violent fluctuations of load inseparable from railway work. It is interesting to note in this connection that Prof. Thomson is now developing a simple arrangement to modify these fluctuations, which will be of great value in reducing the strains on the generator and motors in starting, and incidentally by reducing the electric waves in the lines, to

diminish the inductive effect on neighboring wires. The recent types of dynamos are provided with self-oiling boxes and require very little care or attention while running. So far as can be determined, the durability of these machines is equal to that of the best lighting machines, which is certainly all we can desire.

Voltage.—For the economical transmission of power a high voltage is desirable. For practical reasons, the voltage must be kept within limits perfectly safe as regards danger to life in case of accidental contact. Five hundred volts has been universally adopted as the maximum limit for railway work, this being as high as we can go and still keep well within the limit of safety.

Current.—Up to the present time no form of alternating motor has been devised suitable for railway work, or at least, no practical results in this direction have been made public. Direct currents alone have been used.

Station Equipments.—Each dynamo is provided with an ampère-metre and a circuit-breaker. The station is also supplied with volt metres. The circuit-breaker is adjusted to the ultimate safe limit of current, and is intended as a last resource in case of short-circuit, or over-load to save the armature, the engine or the belt, whichever may happen to be the weakest. When the electric railway was started at Washington in October, 1887, the generator was not provided with a circuit-breaker. In laying the floor of the power station, the carpenter accidentally overturned the incompleted switch-board which was leaning against the wall, resulting in a short-circuit of the dynamo through about eight feet of double-nought wire. Neither the armature nor the belt yielded, but the 100 horse-power engine was stopped. It was several hours before the carpenter could be induced to resume work.

We are now developing a method of automatically preventing any increase of load on the dynamos beyond their maximum capacity. This will do away with circuit-breakers and will be of immense advantage in many ways in the operation of cars. If the railway Superintendent attempts to run cars beyond his power capacity, the result will be, not

to throw the circuit-breakers and stop the whole line for an instant, but simply to reduce the potential or quantity of the current *per car*, and so reduce the speed. The generators will automatically respond to all demands for power, as they do now, until the maximum is reached; but they will absolutely refuse to go beyond this point.

THE CAR EQUIPMENT.

Motors.—The motors in general use have series-wound Siemens armatures. The advantages of the Gramme ring, such as simplicity in repairs and better ventilation for heated armatures, are fully recognized, but the disadvantage of large armatures is a serious one, as the space available beneath the car is limited and the motor must be made very compact, especially in its vertical dimensions. The use of larger car wheels may permit of a change in this respect.

Regulation.—On the question of regulation the various electrical companies do not agree. From a scientific standpoint, the commutated field appears desirable, but there are many practical and commercial reasons in favor of the outside resistance or rheostat. The commercial results of the various roads operating with these two methods of regulation will probably determine in time which is the better, all things being considered. Regulation without commutated fields and without a rheostat would seem to be preferable to either of these methods. Such a system has been devised and is about to be tested in Boston.

Efficiency.—The motors now in use have shown by careful test an efficiency as high as 91½ per cent. The commercial efficiency will, of course, run below this figure.

Location of the Motors on the Car.—The best location of the motor has been, and is still, a disputed question. If the objections are not too serious, I think all will admit that the best position is under the cars, as is now the common practice. The objections are: The difficulty of getting at the motors for repairs, adjustment and cleaning; the fact that being near the ground they are exposed to water, mud, sand, dust, etc.; and that in such position they run without observation, and a slight accident, not being noticed, may result

in considerable pecuniary damage, when, if noticed, it could probably be remedied with but little cost or trouble. We must, and we do, make motors that will run with few repairs and adjustments, and pits or raised tracks should be provided at the car-houses, where the machinery can be cleaned, repaired and adjusted. The practice on some roads of giving the motors a more or less thorough inspection at the end of each round trip is an excellent one and is commended to all railway managers. Thorough and constant inspection is economy in the end, and the good result of this method is shown on one road, where, with ten cars in operation, two months will elapse without a single car being taken to the car-house for repairs.

The exposed position of the motors under the cars is a serious objection. They are usually protected by a sheet-iron pan hung beneath them, and by canvas screens on the sides and ends, and the results seem to show that such protection is sufficient to secure good commercial results. The third objection is a good one. It would undoubtedly be better to have the motor run in full view, but we must remember that the average street-car driver knows but little about electric motors and recognizes the fact that something is out of order only when the motor refuses to work and the car fails to run. Unless a higher grade of men be employed as drivers, the advantage of bringing the motor under their direct observation would be slight.

The use of a separate motor car to haul one or more ordinary cars has been considered; the locomotive to have the motors placed above the floor. There are many advantages in having each car carry its own power, but it is possible that some form of open car similar to the grip car on cable lines may be found practicable, the electrical apparatus being better protected and being more accessible. One great advantage would result from a change in the present method of hanging the motors directly on the axles, that is the possibility of securing better insulation. One serious difficulty would be encountered, that is the question of gearing.

Gearing.—The question of gearing is all-important. The

great majority of roads at the present time are using direct gearing, with one motor to each axle. The wear on the pinions and gears is not excessive, but is a matter for consideration from an economical standpoint. While the noise made by the electric car is not serious, it is of great advantage to reduce it to a minimum, and this is largely a question of gearing. The large intermediate and axle gears are iron with cut teeth. The pinions are either solid or built up. We are now using laminated steel and rawhide pinions, laminated steel alone, solid steel, gun metal, phosphor-bronze and rawhide. Rawhide seems to possess sufficient strength and is practically noiseless. Alternations of wet and dry weather, and extremes of temperature are, however, disastrous, and its use will probably be restricted to equable climates. Laminated steel and rawhide has been largely used, but the advantages of the rawhide do not compensate for the extra expense. Solid and laminated steel give good results—the latter being cheaper and causing less noise, as the ringing sound is broken up. Gun metal is giving excellent results; it makes little noise; the wear on the gear is almost nothing; it is not expensive and when worn out can be sold for old metal at a reasonable proportion of the original cost. It wears faster than some of the other forms, but we can afford to replace it more frequently.

Other methods of gearing have been tried and we have by no means abandoned the attempt to improve upon the present system. The worm gearing, used by Mr. Wharton on his storage battery cars, has given excellent results. It is to be regretted that no exhaustive tests have yet been made as to its efficiency, but this lack of information will soon be remedied. The bearings of the worm are phosphor-bronze and the worm itself is made with a sharp pitch. It is very durable and the wear is slight. It turns readily in either direction and if it shows a proper efficiency, it certainly is worthy of a very extended and thorough trial. Most engineers would probably be prejudiced against this form of gearing, but the ease with which two men can push one of Mr. Wharton's cars is certainly astonishing.

Friction gearing has been suggested, but up to the present time I have seen no practical form. The rapid rotation of the armature, running at times up to 1,500 revolutions a minute and even higher, and the severity of the sudden strains to be applied must not be lost sight of. The conditions are very different from those encountered with a factory shaft. We are now testing a new form of friction gearing which promises good results, and it is expected that something of value in this direction will be developed during the year. If the friction on the rail is sufficient to move the car, there is no good reason why the same principle should not be applied primarily to move the axle.

Sprocket chain gearing has been used, but has been generally condemned. It may be found useful in connecting the two axles, where a single motor is used, as the strain in such cases would be slight and the wear correspondingly diminished. Rope gearing may be found useful in the same way.

We have now working in the Scranton coal mines, an electric locomotive, in which the motor is geared to an intermediate shaft carrying a wheel connected with the two car wheels by ordinary connecting rods. This method has given good results and may be susceptible of further extension.

Trolley.—The trolley arm and trolley wheel, where the overhead system is used, are important elements in the successful operation of the system. All agree that the upward pressing contact is the most feasible, if not the only practicable method. Springs at the lower end of the trolley arm keep the wheel firmly pressed against the under side of the trolley wire. The arm should combine lightness, strength and flexibility. We are using various forms of solid and built up steel, steel tubes, wood and steel, and wood alone. Split hickory with a steel rod in the centre gives very good results.

The trolley wheel is an important detail of the system and care and skill are required in providing for its rapid rotation, for good contact, for durability, and for certainty of operation.

THE LINE.

The conductor may be overhead or underground.

Conduits.—The conduit systems so far have been failures, except when operated under exceptionally favorable conditions. I doubt if any form of open-slot conduit can be devised to meet satisfactorily all the conditions under which tram-cars are operated in this country. Inventors are working on various kinds of closed conduits and we may hope that some practicable system will be ultimately developed, but at present there is little to encourage us in this direction.

Double or Single Wire.—With the overhead system, the first question which arises is, shall double or single wires be used; shall we have a ground return or a complete overhead metallic system? While the double wire is unquestionably feasible on small roads with few or no curves, no cross-overs, turnouts or switches, it is certainly impracticable on any complicated system. It is sufficiently difficult to adjust the frogs, crossings, etc., for a single wire, so that the trolley will automatically follow the car; if we attempt to duplicate these parts with another wire and to insulate the two wires for a 500-volt current, the difficulties are increased to such an extent that they cannot satisfactorily be overcome. The most ardent advocate of the double-wire system has only to look at the crossing of Boylston and Tremont Streets in Boston, or Park or Scolley Square, to have his faith shaken. One has but to draw a diagram of such crossings or even of an ordinary Y, showing the positive and negative wires, to realize the extreme, if not insurmountable, obstacles to such a system. The addition of a second trolley to each car would not be one of the least difficulties. With the single trolley system, the rails, the tie wires and the supplementary wires constitute a metallic return, so that we actually have a complete metallic circuit though but one wire is overhead.

Kind and Size of Wire.—Copper wire is the best on the score of conductivity. Steel would be preferable for strength. Silicon-bronze is frequently used. The larger the wire, the greater the strength and the better the

conductivity; but increase in size entails the disadvantages of greater unsightliness and greater weight. The trolley will work better against a large and heavy wire, but such wire brings increased strains on the poles and cross-wires. The proper mean is not easy to determine, but few roads have been constructed with the trolley wire larger than single-nought B. & S. gauge.

The unsightliness of the wire is a consideration more theoretical than practical; few would notice the difference between No. 0 wire and No. 4 wire when in place.

The wire is supported over the track by cross-wires between two lines of poles, or by bracket arms from one line of poles, where the track is sufficiently near the curb. Various forms of insulating and suspending devices are employed, but the limits of this paper will not permit of any description of details.

The centre-pole system, where the poles are placed between the two tracks, is undoubtedly the best when the street is sufficiently broad to permit its use. The tracks should be separated by a space of six or six and one-half feet. The poles being subjected to a vertical strain only, need not be as strong as side poles, and the whole construction can be made neater, stronger and in many cases cheaper. The Eckington and Soldiers' Home Railway on New York Avenue, in Washington, is constructed with centre poles. The Commissioners of the District of Columbia say of this road: "Of the overhead systems now employed, the Commissioners believe that the one used by the Eckington and Soldiers' Home Railway Company, in which the conductors are supported by poles situated in the middle of the street, is the most satisfactory where there is sufficient width of carriage-way for its employment." An experience of sixteen months has shown that these poles are no obstruction to traffic. No accident has resulted from their location between the tracks.

The District Committees of the Senate and of the House of Representatives have in official reports repeatedly pronounced this road to be the finest in the United States and the centre-pole method of construction is not the least of its

attractions from this official standpoint. Unfortunately in most cities there are few avenues on which such a system is practicable.

The overhead line is one of the most important parts of an electrical installation and no pains should be spared to make it perfect. Do not try to economize on the overhead line. Give it a good margin of safety as regards strength and make it as ornamental as possible.

Feeder Wires.—The trolley wire carries a limited quantity of electricity, proportional to its size and conductivity. When the length of the line or the number of cars running, or the steepness of the grades requires power in excess of the capacity of the trolley wire, feeders are used, running from the station to various points of the trolley wire where re-enforcement is needed. These feeder wires need not of necessity be carried on the same poles or even on the same street as the trolley wire. They may be placed underground, if necessary.

With double trolley wires, a double feeder system is necessary.

Rail Return.—With the single trolley system, the rails are utilized for the return current and each joint is bridged by a tie wire to reduce the resistance and prevent the wandering of the current through the earth. Supplementary wires are also run underground and attached to each tie wire for the same reasons.

Guard Wires.—Where many telephone, telegraph and other lines cross the trolley wires, guard wires should be used to prevent such wires from falling upon the live trolley wires. It is probable that in course of time municipal regulations will be enacted, compelling the telegraph, telephone and other companies to so construct their lines as to make them safe, as has already been done in some instances, but until such action is taken, the railway companies should provide such safe-guards as can be readily constructed. Guard wires generally consist of steel wires stretched parallel to and above the trolley wires. The guard wires may be bare or insulated, but in either case they should be carefully insulated from the trolley wires. On the double track roads

in Boston we use three guard wires, one about fourteen inches above and fourteen inches outside of each trolley wire, and one midway between the other two. These guard wires are suspended from a second span wire above the first and are insulated from the second span wire. With such construction, the chance of a falling wire coming in contact with the trolley wire are so remote that it may be neglected and we may regard the guard wires, when properly maintained, as affording the needed protection.

STORAGE BATTERIES.

But little has been done on any extended scale in the practical application of storage batteries to street-car propulsion. Mr. Wharton has demonstrated the possibilities in this direction and the Julien Company has shown cars in actual operation in New York City. The chaotic condition of the storage battery patents has been responsible to some extent for this condition of affairs. When the atmosphere has been cleared and the various companies realize their exact position on the patent question we may hope for more active developments. At best, however, the storage battery will always be at a disadvantage in comparison with the direct method. It will probably be more expensive and the supply of power on each car being limited, we are in no condition to encounter unusual resistances. Storage battery cars could never have battled with the snow and ice as the motor cars have had to do this winter in Scranton, Minneapolis, Omaha, Council Bluffs, St. Louis, Kansas City, Wichita, and elsewhere.

Considering the electric railway from a commercial standpoint there are five points for primary investigation:

(1) Its feasibility.
(2) Its economy.
(3) Its durability.
(4) Its reliability.
(5) Its first cost.

FEASIBILITY.

By feasibility I mean: Are there any reasons why the public should object to the introduction of electric railways and the municipal authorities refuse to grant the necessary rights? Is it dangerous?

The public have been unnecessarily alarmed as to the dangers of electric wires—lighting as well as railway. No one denies the fact that the arc lighting current is, or may become dangerous to life: but if surrounded by proper safe-guards, if constructed and maintained in accordance with proper rules and regulations, the danger is so slight that I think you will be astonished at the actual figures.

During the past year the deaths from violence in New York City, aggregated 1,467. Of these, 265 resulted from falls; blows from falling objects, thirty-six; run over by horse cars, twelve; run over by cars and engines, thirty-three; run over by wagons and trucks, thirty-two; asphyxiated by gas, twelve; and killed by electricity nine. Yet in New York City the fear of overhead wires has during the past year been aggravated to a most alarming degree.

During the year covered by the last report of the Board of Health, the total number of deaths in Boston from casualties aggregated 399. The railroads were responsible for seventy-eight; sixty were drowned; thirteen were run over by vehicles: nine were killed by elevators; twelve died of the effects of heat, and no less than seventy-eight were killed by simply falling down, of whom sixteen fell down stairs, seven fell on the sidewalk, six fell from buildings, five fell from teams, four fell on the ice, one fell from a chair, one fell from a tree, one fell from a bicycle, one fell from a fence, and so on. Not a single death is recorded against electricity. There are in New England 131 arc-light central stations, which have been in operation from one to ten years, burning over 20,000 arc lamps and distributing thousands of horse-power by wires through and over all the principal cities and towns. During this period there have been but five deaths from electricity. What other industry, comparable with the electric industry, can show such a

record for safety? During these ten years, the steam roads of New England have killed and injured no less than 5,241 human beings. Of the five deaths by electricity, four were employés of the lighting companies and one only can be classed with the public. Of those killed or injured by railroad accidents, 2,339 were employés and 2,902 were general public. Not only is electrical energy shown to be absolutely safer than any similar quantity of energy used in other industries, but in most cases it is relatively safer, as even the few deaths that do occur are among the employés and in general, are caused by neglect of instructions and failure to observe the necessary precautions.

Another objection urged against electricity is the danger of fires. It is common now to attribute every fire to electric wires when the cause is not clearly apparent. Let us examine the statistics on this point for the past few years.

Since the establishment of the office of Fire Marshal in Boston, its present incumbent has investigated in the most thorough manner every fire, and has given us a record as to causes probably as complete as it is possible to obtain. From November 8, 1886, to May 1, 1887, 344 fires were investigated, of which only five are returned as "cause unknown." The kerosene lamp caused thirty-two; rats and matches are responsible for eleven; dropping of matches, twenty-seven; children and matches, thirteen; careless use of matches, twelve; overheated stove, sixteen; hot ashes from tobacco pipe, ten; lighted cigar stumps, six; sparks from locomotive, three, and electric wires, three. Electricity caused ·009 of the fires. For 1888, we find the same record for kerosene, matches and rats and matches, while electric wires are responsible for only ·007 of the fires. In the 1889 report, sparks or heat from furnaces, locomotives, steam-pipes, etc., are responsible for fourteen per cent. of all the fires; kerosene stands well up with thirteen per cent., while matches in conjunction with men, rats and children, are responsible for twenty per cent. of all the fires. Electricity comes in with a modest two per cent., being on a par with hot ashes, and twice as harmless as fire-crackers and fire-works.

It would seem that such a record should exonerate the electric wires from the charges brought against them.

The above refers to electric wires in general. Now a few words as to the electric railway wires.

While the arc light wires carry currents of from 2,000 to 6,000 volts, the railway wires carry a current of only 500 volts. This voltage is fixed, and the quantity of electricity varies according to the needs, *i.e.*, according to the number of cars running.

It is an incontestable fact that no man, woman or child has ever been killed, or even seriously injured, by a 500-volt current, though many have been subjected to the shock. Every alleged case of death or injury by railway wires has, upon investigation, been shown to be without foundation, or else to have been caused by the arc current. As illustrating this point, I might cite the case of the colored boy said to have been killed by the railway wires at Chattanooga. He was found in a pit beneath the car he had been employed to clean, with his clothing on fire and an overturned oil lamp between his legs. He burned to death. This occurred in the night, an hour and a half after the road had ceased running and the power station had shut down. There was no current in the wires, and had been none for an hour and a half, yet this death has been repeatedly ascribed to railway wires. While hundreds have taken the full 500-volt current, no one, not even a child who held a contact wire for four minutes, has ever been seriously injured.

In the report of the Commissioners of the District of Columbia on the Eckington Railway, from which I have heretofore quoted, they state: "The Commissioners believe that the electrical system employed by this railway, the electro-motive force of which can never exceed 500 volts, is as safe as any motive system ever employed by any railway. The Eckington Railway has never had any accident whatever resulting from its employment of electric motive-power, and the Commissioners believe this to be also true of all other electric railways now in operation throughout the United States."

As to danger of fire, since the railway wires enter no buildings, they cannot of themselves cause fires. The current might be conveyed through some other circuit by wires falling on the trolley wires. Without discussing the law and equity of requiring such wires, when they cross the streets or cross other wires, to be so put up that they will be safe, it suffices to say that by the use of guard wires we prevent falling wires from coming in contact with the trolley wire, and the chance of a railway wire causing a fire, either directly or indirectly, is so remote that it will probably not be found worthy of a separate classification in the list of "causes." Every electric wire entering a building should be provided with a fuse or a short-circuiting device, so that stray currents of greater voltage or quantity than the normal will be effectually cut off.

Increased speed does not necessarily mean increased danger to other vehicles, pedestrians or to those who ride or drive. In the city of Pittsburgh, Pa., is a cable road, on a heavily-travelled street, only thirty-six feet wide, in the heart of the city. A double-track road on this street leaves about nine feet between the outer rail and the curb on each side. Formerly the cars were run at the rate of seven miles per hour; some time ago the speed was increased to nine and one-half miles per hour. The records show that there are actually fewer accidents with the present speed than with the former, and this for a period that establishes the accuracy of the statistics. The result is easily accounted for. Pedestrians and drivers of vehicles take great care to avoid the fast-running car, while they are more or less careless and indifferent when the speed is slow.

ECONOMY.

Even were electricity as expensive as horse-power, its numerous advantages would ultimately result in its general adoption, but as a matter of fact, it shows a very considerable saving over horse-power. This is to be expected. If we have one source of power—one power station—instead of a thousand, we ought to generate the power at a less cost. If we have efficient motors and a well-constructed

line, we should expect to utilize this power with little waste. Of 100 horse-power produced in the steam-engine, ninety-two is converted into electricity and goes out of the station over the line as electrical energy. The loss in the line need not exceed ten per cent., though in some cases it may be economy to allow a larger loss. We thus have 82·8 horse-power delivered to the motor on the car. If the commercial efficiency of the motors and gearing be seventy-five per cent., we have 62·1 per cent. horse-power utilized in moving the car, or a total efficiency of 62·1 per cent. Of course, we may fall below this figure. The actual power required per car depends upon the grades, the speed, the curves, the kind and condition of track, the size and weight of the car, the average load, etc., conditions so variable that it is hopeless to try to determine any average figure. The power will range from four horse-power to nine horse-power under ordinary conditions, and may increase very considerably under extraordinarily bad conditions. The cost of power at the station depends upon the kind and size of the engines, the price of coal, the management of the station, etc. It ranges as low as nine-tenths of one cent per car mile, and as high as seven cents per car mile. The latter is a very extreme case and does not represent the actual cost. This price is paid for power for a single car operated under the most disadvantageous conditions; this car, however, yields a better return to the railway company than any other car on its entire system. This indicates that a high price is not always incompatible with economical results. The cost of repairs depends very largely upon the care bestowed upon the apparatus, and any figures given without a full statement of all the special conditions would be misleading. I have known the cost of material for repairs on a large road to run as low as nine mills per car mile for one month, and I have known it to go very much higher.

Speed is not only an important factor in determining the value of electric railways to the public, but it is equally important to the railway manager as a source of economy. If we average six miles per hour with horses and nine miles

per hour with electricity, it is evident that in the latter case one car does fifty per cent. more work with a corresponding saving in the item of wages of conductors and drivers.

In the crowded city streets we cannot hope to gain much speed. In the suburbs the gain is only limited by considerations of safety. From Harvard Square, in Cambridge, to the end of the line, in Arlington, the electric cars average about eleven miles per hour, including stops—better time than is made by the elevated roads in New York City. On the Watervliet Road, between Albany and Troy, the following is the record of one month's work:

MILEAGE OF WATERVLIET CARS, DECEMBER, 1889.

Average number of cars in daily service,	7¼
Total mileage, thirty-one days,	31,340
Average daily mileage,	1,011
Average daily mileage, per car,	139

On December 20, 1889, we have the following record of five cars:

	Miles.
Car No. 43 made a total of,	180
" 44 " "	190
" 45 " "	190
" 46 " "	190
" 61 " "	180
Grand total,	930
Average per car,	186

On January 3, 1890, we have the following record of five cars:

	Miles.
Car No. 40 made a total of,	190
" 42 " "	190
" 44 " "	190
" 60 " "	180
" 62 " "	180
Grand total,	930
Average per car,	186

This is an imposition upon the motors. It is requiring more than we ask of the steam locomotive which runs under the most favorable conditions as to grades, curves and

track. I give these figures as an instance of what can be done and what is done, not as an example of what should be done. We must be reasonable and not work the willing horse to death.

Increased speed is a great boon to the public always clamoring for rapid transit. By the aid of electricity we have increased the average speed of the cars in Boston from six miles per hour to eight miles per hour and were all the cars equipped electrically this increase alone would make an annual saving to the passengers of 4,152,000 hours or about 474 years. Think of this as one year's saving in one city resulting from the use of electricity as a motive-power for street cars. As a matter of fact the gain in speed will be greater when all the cars are equipped, as the average is now kept down by the horse cars holding back the electric cars running on the same tracks.

The increased speed should not be lost sight of in comparing the cost of operating electric, with the cost of operating horse cars. A comparison on the basis of car days is not a just one. The comparison should be made on the basis of car miles. On the Watervliet road the daily mileage per car has been nearly doubled by the use of electricity.

Another economical feature of the use of electricity is the ability to haul one or even two tow cars. We can double or even treble our carrying capacity in case of emergency; and the extra plant kept for such purposes is in the cheapest form, representing a comparatively small invested capital, and subject to but little deterioration. Compare this with the cost of keeping extra horses sufficient to double or treble our carrying capacity. The difference is enormous.

On those roads or lines where the traffic is great and constant, we will have larger cars. By using the radial truck or double trucks, we can handle thirty-foot cars as easily as our present standard form, and do away with the annoying and destructive teetering inseparable from a long car mounted on a six-foot truck. We can nearly double the seating capacity, and still use but one conductor and one driver.

From the foregoing, it is evident that electricity admits of many economical changes, and that, in many ways, we may hope to reduce expenses by its use, at the same time giving better service. What we must look to, of course, is the ultimate commercial result. Whatever may be said pro and con, the commercial result must be the final criterion. We are now receiving some light in this direction from the annual reports of the roads in those states where the statutes require such reports. Such statistics are of of great value, for whatever difference may exist as to classification and arrangement, the total expenses and the total receipts are bound to appear in some form or other. From the reports of the Railroad Commissioners of New York and Massachusetts for the year 1889, we extract the following:

EXPENSES OF STREET RAILWAYS, NEW YORK STATE, 1889.

Horse Roads.—Average proportion of receipts to operating expenses, thirty-three roads, 79·39 per cent.

Electric Roads.—Average proportion of receipts to operating expenses, two roads, 53·50 per cent.

EXPENSES OF STREET RAILWAYS, MASSACHUSETTS, 1889.

Horse Roads.—Average proportion of receipts to operating expenses, thirty roads, 82·87 per cent.

Electric Roads.—Average proportion of receipts to operating expenses, two roads, 55·50 per cent.

In 1888, the gross earnings and operating expenses of surface and elevated roads in three states were as follows:

RECEIPTS AND EXPENSES PER PASSENGER, 1888.

	Gross Earnings.	Operating Expenses.	Net Earnings.
	cents.	*cents.*	*cents*
Elevated Roads.—New York State,	5·01	2·81	2·20
Surface Roads.—New York State,	4·94	4·02	·92
Third Ward Electric Railway.—Syracuse (1889),	4·92	2·78	2·14
Surface Roads.—Pennsylvania,	5·59	3·18	2·41
Surface Roads.—Massachusetts,	5·10	4·28	·82
Boston and Revere Electric Railway (1889),	4·70	2·71	1·99

The column of operating expenses contains some very significant figures.

Such figures are more convincing than any labored argument. In time, as we have more of these reports, the sceptical will become convinced and the doubting will be satisfied.

DURABILITY.

We may recognize the present economy of electrical power; but, we ask, will the apparatus last? Is it durable? Will it not wear out in one year, two years or three years?

It is difficult satisfactorily to answer such questions. A Van Depoele road was put in operation at Lima, O., July 4, 1887. So far, the apparatus has shown no signs of wearing out. The Eckington and Soldiers' Home Railway, in Washington, was started October 17, 1888. Senators and Representatives still say it is the finest street railway in this country. The Omaha and Council Bluffs Railway was opened to traffic in October, 1888, with ten cars (twenty motors). I am informed that, of these original motors, not a single armature or field has been lost, with the exception of a few struck by lightning before being properly wired for the lightning arresters.

There are certain parts which we expect to wear out; the gears, the shells in the bearings, the trolley wheels, and so forth; but these are provided for. The iron frame of the motor has no wear, and should last indefinitely, unless accidentally broken. The fields and armature are not subjected to wear, and should last indefinitely, unless burned or injured by accident. The electrical part of the apparatus is all right; the wear is mainly on the mechanical parts. It is the mechanical rather than the electrical engineer that we look to now for improvements. When it is generally recognized that we have, to a great extent, eliminated the electrical difficulties and reduced the problem to one of mechanics, the street railway companies will be ready to push forward with full confidence.

RELIABILITY.

That some difficulties are encountered in the operation of electric cars cannot be disputed. Even though these difficulties, these mishaps, these accidents, be slight, if

they interfere materially with the regular operation of the cars, if they cause breaks in the schedule, then they are matters for serious consideration, and perhaps for more serious consideration than the actual cost of repairs involved. The public are exacting in this respect, and will not tolerate delays and unreliable service. It is difficult to secure data in reference to lost trips on roads which are operated independently of the electric companies. On the West End Road, in Boston, during the months of June, July, August and September, of last year, 33,665 round car trips were made, covering a total mileage of 364,754 miles. *Not a single trip was lost.* This is certainly a satisfactory record as to reliability. Similar results have been obtained on many other roads; but the West End is, perhaps, one of the most difficult of all the roads to operate electrically.

On a purely electric road, if a car breaks down from any cause, the next car pushes it home and the delay is slight. I saw one day in Boston a string of horse cars blocked by the cutting of a ditch across the street. Each car, as it came up, had the horses removed and driven around, while the car was pushed across by hand. This entailed much delay, and five cars were soon collected in line. Then an electric car came along, the horses were all removed, and the electric car pushed the five cars across at once. Here was an unexpected example of how time may be saved by electricity.

The success of the electric cars in snow-storms is remarkable. It is really astonishing to see the cars running through twelve inches of snow with no apparent difficulty, frequently pushing or pulling other cars, while four steaming horses are hardly able to pull one car. The contrast is great, and many who were doubtful about the ultimate value of electricity last fall are most enthusiastic advocates now. Such work requires extra power and the station must be able to meet the demand.

During the recent blizzard in St. Paul, one of the criticisms on the electric road was, that the drivers lost their heads and cut down the schedule time of the round trip from forty-five minutes to thirty-five minutes—certainly not a

cause for serious complaint. In St. Louis, in Wichita, in Kansas City, in Scranton, in Syracuse, and elsewhere, the electric cars have this winter demonstrated their decided superiority over horse cars, and have shown their ability to run through ten or twelve inches of snow without requiring the tracks to be cleaned. The electric sweepers in Boston are a pronounced success, and the press, the public and the railway officials are unanimous in their praise. We feel confident now that electric cars can run when horse cars cannot, and that it will require such an unusual storm as stalls the steam roads to block electric cars.

To insure reliability, the entire system should be constructed and installed in a first-class manner; duplicate or reserve steam and generator capacity should be provided; extra motor cars should be held in reserve, the proportion depending upon the nature of the service required; and extra parts should be kept on hand, so that an accident can be repaired in the shortest possible time. We should realize that to a certain extent the motors take the place of horses. A motor may fall sick occasionally, and the services of an electrical doctor should always be available.

FIRST COST.

If electricity does all that is claimed for it, then it is a necessity in street railway work. If the railway President investigates and finds that the claims are well supported, that electricity is safe, is economical, is durable and is reliable, then he seeks to know the cost. A really good article is expensive. Electric motors are good articles.

The cost of equipment for a first-class, double-track road, including iron poles (side suspension), fifty-six pound girder rail, one sixteen-foot closed car and one open tow car to each mile of track, suitable generator and steam plant capacity, etc., would be approximately as follows:

PER MILE OF TRACK.	
One mile of track (paved street), ...	$10,000
One motor and one open tow car, generator and station equipments, line construction, including poles and steam plant, ...	10,000
	$20,000

A double-track road ten miles long would cost on this basis $400,000, including twenty motor cars and twenty tow cars.

On a road with very bad grades, greater power might be required. If wooden poles be used, the cost of the line would be very materially reduced.

And now a few words as to the future of electric railways. The success of electrical propulsion has been established beyond question. It is only a matter of time, and that a short time, when it will replace the horses on the majority of our street railways. It is only a matter of time, a somewhat longer time, perhaps, when it will be the propelling power on all our elevated roads, for the elevated roads possess ideal conditions for the application of electricity. It is within the bounds of possibility that our steam roads will be run with electricity; certainly this power offers many advantages for the suburban traffic in the vicinity of the large cities. The possible utilization of hitherto neglected water-powers will be one of the factors in determining the extension of electrical propulsion in this direction. Already we see the beginning. The West End Company, of Boston, are building longer cars with radial and double-swivelled trucks. The New York elevated roads are anxiously seeking a solution to the problem of how to enlarge their carrying capacity without rebuilding or materially altering their superstructures. Longer trains are requisite to meet the increased demands. The limit of the capacity of the present locomotives has been reached. Increased weight in the locomotive means are immense expenditure for strengthening or practically rebuilding the roadway. Cables are not feasible, as the strain on the grip would not permit of long trains and it would be difficult to combine speed and safety with any considerable increase in the number of trains. Cables would not permit of satisfactory switching arrangements at the termini and elsewhere. Electricity offers the best solution. Equip each car with motors. Flexible electrical connections can easily be made from car to car as is now done on surface roads to light the tow cars, and the whole train controlled by the driver on

the front platform of the leading car. Electric, vacuum, or air brakes can be used in the same way. It matters not how many cars we have in a train—one or fifty: Each car adds its own power and all work together. There is no dead weight to pull, as in the case of the locomotive. The passengers themselves furnish the weight for traction. The switching arrangements present no difficulties whatever. The motors can be reversed and run equally well in either direction. The train can be controlled from either end and any increase or decrease in the number of cars will not affect the controlling mechanism.

It is difficult to conceive of a more flexible system. It seems to be the ideal system for the elevated roads and is bound to be adopted in the near future.

On a New Method of Measuring the Heat of Vaporization of Liquefied Gases.*

By E. Mathias.

[Translated by Chief Engineer Isherwood, U.S.N.]

The calorific methods ordinarily employed are the methods *with variable temperature*, or at the *fixed* temperature of melting ice; but for the object of my researches a calorimetrical method with *constant temperature*, was necessary, and to give different values to that temperature.

With this view I compensate at each instant by means of a known source of heat the cooling of the water calorimeter due to the vaporization of the liquid. That source is the heat developed by the dissolution of a known weight of concentrated sulphuric acid in the water of the calorimeter. The proposed method is thus a *method of zero;* and *it is susceptible of generalization in other ways.*†

* *Comptes Rendus*, 1888, p. 1146.

† There can evidently be taken as the source of heat the dissolution in water of hydrochloric acid, of azotic acid or of any well-adapted solid; the

This is the first time I believe that such a *calorimetrical method with constant temperature* has been proposed and applied; its advantages are evident when the problem is to ascertain the heat of vaporization, which is a function of the temperature and varies very rapidly with that of the surroundings at the critical point. At the end of the experiment, as at all the intermediate epochs, the temperature of the calorimeter, and consequently that of the liquefied gas, is the *initial* temperature $t°$; the vaporization is always effected at $t°$ and under the pressure p of the saturated vapor. Be

P the weight of liquid vaporized;

Q the heat furnished to the calorimeter, correction made for the cooling;

λ_t the heat of vaporization at $t°$.

Then—

$$\lambda_t = \frac{Q}{P}.$$

The essential part of the apparatus employed is a copper, cylindrical recipient R, closed at the bottom and communicating at the top with a pipe of very small diameter coiled around it. The pipe of this coil has a length of about one metre. The whole is placed in a Berthelot calorimeter and is *gilded externally* to prevent attack by the acid. The reservoir is strong enough to resist a pressure of 100 atmospheres. The coil is soldered to a first cock A, having a nickel-plated pointer, which communicates with a second cock B and with a sensitive manometer. The gas, on leaving B, passes through a tank of glycerine, which allows the regularity of the vaporization to be observed. The thermic

heat of dissolution is to be determined directly for the body used. Mr Charles Fabre first employed the dissolution of sulphuric acid in water for introducing a known quantity of heat into a calorimeter. (*Annales de Chimie et de Physique*, t. x, 475.) More recently, Messrs. Berthelot and Recoura have also used it for determining the value in water of the calorimetrical bomb. (*Comptes Rendus*, t. civ, p. 876.) But these interesting precedents do not constitute a distinct calorimetrical method, such as the method of compensation described above.

isolation of the recipient R is realized by means of a lagging of *celluloid*, a material more non-conducting than wood.

When the resevoir and the calorimeter have the temperature of the laboratory, and the cooling is very slow, the experiment is commenced by opening the cock A, the second cock being closed. The manometer indicates the pressure p of the saturated vapor at the temperature $t°$ of the experiment. The cock B is then gradually opened and the flowing out of the gas is so regulated by it as to make a pressure $p - e$ constant; the diminution of the pressure p can be made as small as desired, and in varying it the expenditure is varied. The expansion is thus reduced to a minimum. At the end of the experiment the cock B is suddenly closed; the pressure quickly rises, not to the primitive value p, but to a value $p - e$ a little less, and which is the tension of the saturated vapor at the temperature t' of the interior of the recipient, a temperature a little lower than the constant temperature of the calorimeter; then, the apparatus becoming reheated, the pressure rises to its initial value p. The knowledge of e' allows the calculation to be made of the lowering $t - t'$ of the initial temperature; this has not exceeded 0·3° in the following experiments.

During the whole time of the vaporization the sulphuric acid is delivered from a glass flask resting on scales, drop by drop into the calorimeter, care being taken to mix it with the water. In this manner, and with proper precautions, the temperature can be maintained nearly constant, varying at the most only 0·05° on either side of the initial temperature; further, care must be taken that this variation is alternately positive and negative in order that the mean temperature may be $t°$.

When the heat of dilution has been experimentally determined, the knowledge of the weight of acid used enables the heat furnished to the liquefied gas to be exactly known. From the diminution of the weight of the recipient R the weight P of the liquid vaporized is easily deduced. All the data is then had for knowing λ_t. By operating at different temperatures the variation of the heat of vaporization with the temperature will be found.

I have applied this method to sulphurous acid and the following are the results obtained:

p.		*Weight of Liquid Vaporized. Grams.*	*Latent Heat Observed Calories.*		*Latent Heat Calculated Calories.*
5·74°		30·987	89·3		89·67
9·44		11·936	88·0		88·24
10·525		25·960	87·1		
10·500	10·500	33·798	87·4	87·3	87·84
10·445		20·314	87·3		

From the above will be seen that the heat of vaporization decreases when the pressure increases. It is interesting to compare the numbers furnished by experiment with those given by the formula of Clapeyron:

$$L = \frac{T}{E}(u' - u)\frac{dp}{dt}$$

These numbers have been published in an anterior investigation* made in conjunction with Mr. Cailletet. I have essayed to represent them by calculating by the method of least squares a formula of three terms

$$\lambda = a + b\,t + c\,t^2,$$

by the aid of thirteen heats of vaporization from 0° to 60°. There are thus represented in a satisfactory manner the numbers calculated by the formula

$$\lambda = 91{\cdot}87 - 0{\cdot}3842\,t - 0{\cdot}000340\,t^2$$

It will be seen that from 0° to 40° or 50° the term in t^2 is negligable, and that the heat of vaporization can be represented by the linear formula

$$\lambda = 91{\cdot}87 - 0{\cdot}3842\,t.$$

For $t = 0°$ there is found $\lambda = 91{\cdot}87$ calories, a number nearly identical with the value 91·7 calories found by Mr. J. Chappuis. The same formula also very well represents the numbers that I have given above, as shown in the fourth column of the above table.

I have cited the preceding numbers in order to take date, the method offering above all an interest for the gases

* Cailletet and Mathias. *Comptes Rendus*, t. civ, p. 1563.

which, like ethylene, carbonic acid, and the protoxide of azote, have their critical points at ordinary temperatures. These are the bodies that I propose to investigate, and with the Academy's permission, I will communicate to it the results of my researches on this subject.*

ON THE HEAT OF VAPORIZATION OF LIQUID CARBONIC ACID NEAR ITS CRITICAL POINT.

BY E. MATHIAS.†

[Translated by Chief Engineer ISHERWOOD, U.S.N.]

In a preceding note‡ I described a method of measuring, *at constant temperature*, the heat of vaporization of liquefied gases, the source of the compensating heat being the heat of dilution of sulphuric acid in the water of the calorimeter.

I have applied this method without modification to sulphurous acid, to carbonic acid, and to the protoxide of nitrogen, within the limits of the atmospheric temperatures of the room in which I operated (+ 2·5° to + 22°).

In order to operate between + 22° and the critical point (+ 31°) of carbonic acid, the method was modified in the following manner:

By means of a suitable system of burning gas jets fitted with regulators, I raised the temperature of the operating-room a little above the temperature $t°$ *at which I wished to experiment*, and I maintained this raised temperature constant. I then filled the outer space of the Berthelot calorimeter with water of the same temperature, and, finally, I filled the calorimeter with water at $t°$, and closed it by a cover through which the vertical tube from the reservoir of the liquefied gas passed. A sensitive thermometer showed

* The work has been done in the laboratory of the physical school at the Sorbonne.

† *Comptes Rendus*, 1889, p. 470.

‡ *Comptes Rendus*, 1889, p. 1146.

the temperature of the water in the calorimeter and of the liquefied gas in the reservoir. There was then established between the air of the room, the outer space of the calorimeter, and the calorimeter itself, an equilibrium such that, if all the conditions were adroitly adjusted, the temperature of the calorimeter would vary with extreme slowness. With a little experience the water of the calorimeter could be brought within 0·05° of the $t°$ and maintained there. Under these conditions, I raised the cover of the calorimeter and proceeded with the experiment as at ordinary temperatures to that near which the rapidity of cooling is a little greater. The sole inconvenience of this method is that the experimenter is obliged to be under the temperature $t°$ of the experiment.

Denoting by P' the diminution of the weight of the reservoir of the liquefied gas, the weight P of the liquid vaporized at $t°$ is given, as has been shown* by the formula

$$P = P' \frac{\delta}{\delta - \delta'},$$

δ and δ' being the densities of the liquid and of its saturated vapor at $t°$.

In the neighborhood of the critical point, the coefficient $\frac{\delta}{\delta - \delta'}$ has very large values, and the weight P of the gas which passes off should be more and more lessened in order to prevent too great a discharge and consequently expansion.†

As the liquefied gases, although prepared with the

* J. Chappuis, *Comptes Rendus*, 1887, p. 897.

† It will be sufficient to discharge the gas in the Bourdon manometer which indicates the pressure, the second cock being closed and inoperative. Previous experiments gave the weight of gas corresponding to the indications of the manometer. The weight of liquid vaporized can thus be exactly regulated. In order to avoid expansion, I generally limited myself in the definite experiments to the vaporization of only the weight of liquid comprised between ¼ and ½ gram per minute (discharge = 15 to 20 minutes). There are thus developed but small quantities of heat, and the interior cooling of the apparatus, which is difficult of measurement in the case of high pressures, becomes negligable.

greatest care, always contain a little air, they have to be analyzed, and denoting by a the proportion of air thus found, the numbers ascertained for the heat of vaporization must be augmented in the ratio of a in 100.*

I have thus determined the heat of vaporization of carbonic acid with three samples of the liquid independently prepared by myself, and containing, respectively, 0·71, 2·15 and 0·76 per cent. of air.

The following are the numbers obtained, correction being made for the air:

Temperature t° of the Carbonic Acid.	*Heats of Vaporization Experimentally Determined in Calories.*	*Heats of Vaporization Calculated by Formula in Calories.*
6·65	50·76	51·05
12·35	44·97	45·23
16·46	39·92	40·30
22·04	31·80	32·00
26·53	22·50	22·80
28·13	19·35	18·34
29·85	14·40	11 64
30·59	7·26	7·01
30·82	3·72	4·61

The third column contains the numbers calculated by the formula—

$$L^2 = 118{\cdot}485\,(31 - t) - 0{\cdot}4707\,(31 - t)^2,$$

deduced by Messieurs Cailletet and Mathias† from the well-known formula of Clapeyron—

$$L = \frac{T}{E}(u' - u)\frac{dp}{dt}$$

and the ascertained values of u, u' and $\frac{dp}{dt}$

The accord of the numbers experimentally determined

* The heat of dissolution of the air in the liquefied gas is also neglected. More exactly $L' = L\,\frac{100}{100 - a}$, L' and L being the crude, uncorrected numbers.

† Cailletet and Mathias, *Journal de Physique*, 2d series, vol. v, 1885, p. 562. The formula in L has allowed the foreseeing of the heat of vaporization at zero, which has recently been determined by Mr. Chappuis, *Comptes Rendus*, 1888, p. 1007.

and calculated by the formula is, I may say, *a very* satisfactory verification of the formula of Clapeyron.

If a curve be constructed having the temperatures for abscissas and the experimentally determined numbers for the ordinates, the tangent to the curve at the critical point will be found perpendicular to the axis of the abscissas, from which the conclusion would seem to be warranted that *at the critical point the latent heat is rigorously nothing, and, consequently, that at the same temperature the equality* $u = u'$ *is also perfectly rigorous.*

There can be drawn from the above propositions other immediate deductions, which will be given in a future memoir.

THE HOLLERITH ELECTRIC TABULATING SYSTEM.

[*Report of the Committee on Science and the Arts.*]

[No. 1,458.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 2, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

THE HOLLERITH ELECTRIC TABULATING SYSTEM,

Report that: The Hollerith Electric Tabulating System is a device by which electricity is applied to the compilation and tabulation of census and other returns of a similar nature which require summation and classification under various heads and in different groups.

The methods consist essentially in first recording the data relating to each person by punching holes in sheets or strips of electrically non-conducting material (paper), and then counting or tallying these data either separately or in combination by means of mechanical counters operated by electro-magnets, the circuits through which are controlled by the perforated cards or strips.

When the returns containing the record of each person have been received from the enumerators of the census, each record is transcribed by punching, to a manila card, 6⅝ x 3 inches. These cards have one corner cut off diagonally, to ensure proper arrangement of the cards when piled together, the number of the corresponding record having previously been written on the card for the purpose of identification. The state, enumerator's district, etc., are recorded on the cards by a certain combination of four or five holes at one end of the card reserved for that purpose. As this combination of holes will be the same for all the records from a given district, a special machine is arranged which punches all these holes through four or five cards at one operation, thus reducing the labor involved to a minimum. These holes serve positively to locate a card in its proper district. A card misplaced among a thousand can readily be detected by the fact that one or more of these holes would not correspond with the balance of the cards. The importance of this consideration is manifest.

In order to punch the individual records upon the cards, they are placed one by one in a suitable punching machine. This machine is arranged with a plate of metal pierced with numerous holes, each hole or combination of holes corresponding to the fact to be recorded; and the given record is transferred to the card by punching from it, holes, corresponding to the proper holes in the plate. The order in which the facts to be recorded are punched is in general conformity with that in the records, so that, beginning with the left, the card is punched for race, sex, age, relation to head of family, conjugal condition, occupation, education, physical condition, birthplace of father, and birthplace of mother. In this manner, there is obtained a complete record which will answer mechanically all questions which can be put to it. If desired, these punched record cards can easily be read and verified, by simply placing them over printed forms prepared for the purpose.

The tabulation of the facts thus recorded on the cards is accomplished as described below. The press, shown in the diagram (*Fig. 1*), consists of a hard rubber bed-plate provided

with suitable stops or guides against which the cards are successively placed. The bed-plate is formed with a number of holes or cups, corresponding in number and arrangement with the holes that may be punched on the card. Each cup is partly filled with mercury, and connected with a binding post on the back of the frame (*Fig. 2*). Above the hard rubber plate is a reciprocating box provided with a number of projecting spring-actuated contact points, corresponding in position with the centres of the mercury cups. When a card

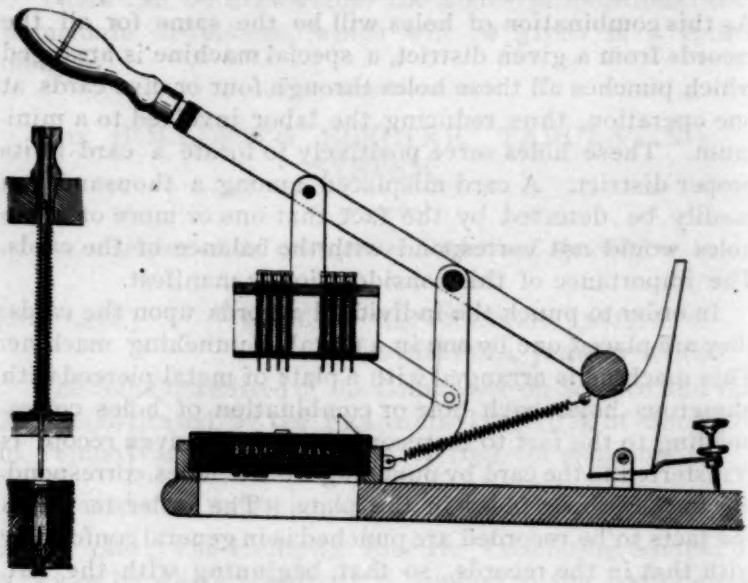


FIG. 1 Diagram showing Construction of Press, or Circuit-Closing Device.

is placed in the press, and the handle brought down, these pins will form circuits corresponding to the punched record.

Arranged in a suitable frame (*Fig. 3*) are a number of counters, each capable of registering to 10,000. These counters are actuated by electro-magnets terminating in binding posts on the back of the counter frame.

To tabulate any of the facts recorded on the cards, it is only necessary to connect the corresponding binding posts with the binding posts of the counters, and then pass the

cards through the press, when the results will be shown directly on the counters. The number of facts thus recorded, at any one operation, is only limited by the number of counters which are used.

If, while certain facts are thus being tabulated, it is desirable at the same time to sort or arrange the cards according to any data, as for example, nationality, a sorting box (*Fig. 4*) is employed. This box is suitably divided into twenty-four compartments, each of which is closed by a lid, held against the tension of a spring, by a catch which forms the armature of

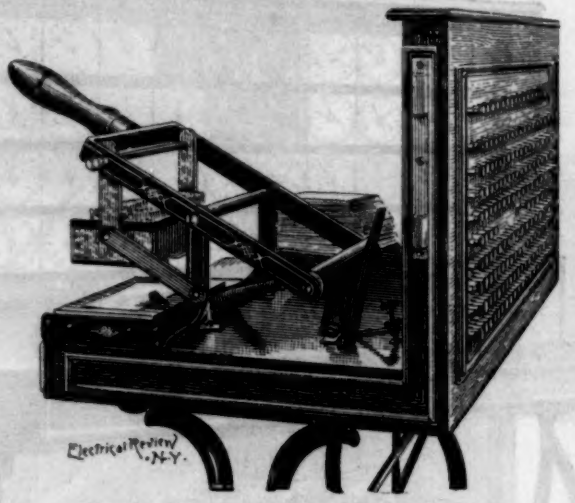


FIG. 2.—Press, or Circuit-Closing Device.

a suitable magnet. If desired, the number of compartments may be increased. These magnets are connected with the binding posts of the press according to the data by which the cards are to be assorted. When a card is put in the press the armature corresponding with the given record is attracted, thus releasing the corresponding lid, which remains open until the card is deposited in that division, and the lid again closed by hand. This is done with the right hand, while with the left hand another card is being put in position in the press. The sides of the sorting box are hinged to permit the easy removal of the cards when assorted. The

sorting of the cards can be done while at the same time counting any desired group or groups of facts.

A series of checks upon the accuracy of the machine's record can easily be applied. (*a*) In recording a given series of facts upon a number of dials, one dial is always so connected that it will record every card that passes. The reading of this dial must therefore equal the sum of the readings of all the others. (*b*) Every time the circuit is closed in the act of registering the facts upon a card, a bell strikes.

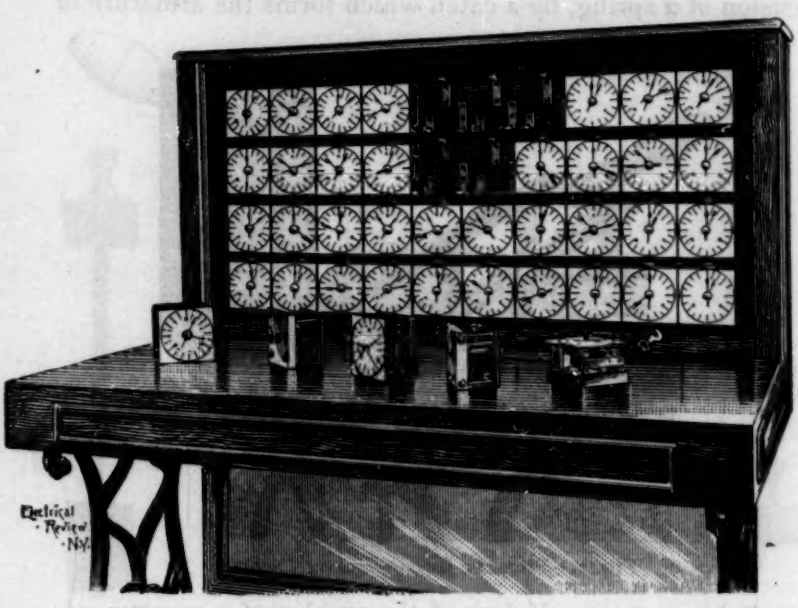


FIG. 3.—Counters.

The failure of this bell to sound is therefore a warning to the operator that for some reason the card has not been registered. (*c*) If by accident a card is placed under the press upon which is recorded none of the facts at that time being enumerated the machine will refuse to register. (*d*) All the cards that rightly belong to any one of the sorting boxes will have at least one hole in common (besides those noting the district), and a piece of wire may be thrust through this hole if the cards are piled together in order. Inability

to do this shows that one card has been placed in the wrong box, and the intruder can at once be thrown out.

A commission appointed by the Superintendent of the Census, instituted a comparison between three methods of compiling census returns; Mr. Chas. F. Pidgin's method called the "chip system," Mr. Wm. C. Hunt's method by means of cards and tally sheets, and the method of Mr. Hollerith. The test selected was the re-tabulation of certain returns from the census of 1880, from four districts containing 10,491 inhabitants. The following results are quoted from the Commission's report:

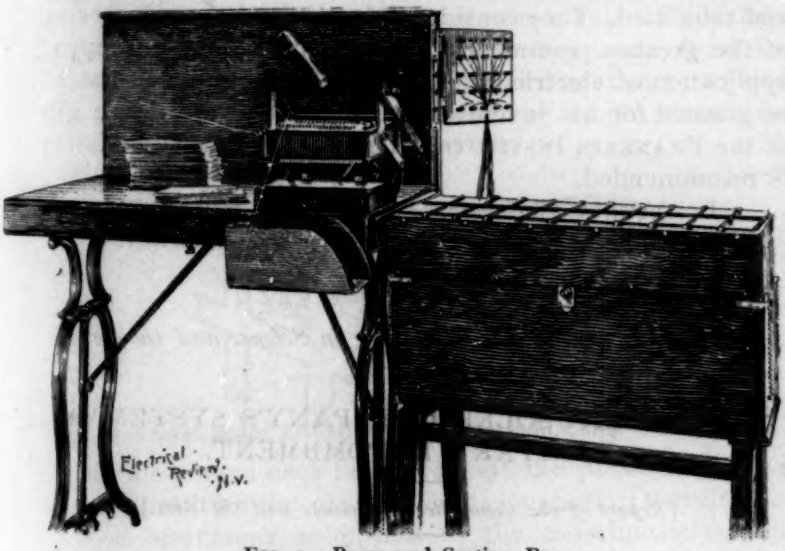


FIG. 4.—Press and Sorting Box.

TIME OCCUPIED IN TRANSCRIBING.

By punching, Hollerith's method,	72 h. 27 min.
On slips, Hunt's method,	144 h. 25 min.
On "chips," Pidgin's method,	110 h. 56 min.

TIME OCCUPIED IN TABULATING.

By electrical machine, Hollerith's method,	5 h. 28 min.
By sorting slips, Hunt's method,	55 h. 22 min.
By sorting "chips," Pidgin's method,	44 h. 41 min.

The Commission further report that Hollerith's method of tabulating is superior to both the others in accuracy.

They estimate that its use in compiling the returns of the eleventh census will result in a saving of $579,125. The cost of compiling a census by the Hollerith system, would appear to be only one-third the cost of compiling the same census by the next best system.

Your Sub-Committee have made an examination of the Hollerith system in Washington, where they saw it in operation, and they are of the opinion that it is invaluable wherever large numbers of individual facts are to be summed and tabulated. They consider that the inventor is deserving of the greatest commendation for this useful and novel application of electricity, and strongly recommend that he be granted for his invention the highest award in the gift of the FRANKLIN INSTITUTE. The ELLIOT CRESSON MEDAL is recommended.

L. D'AURIA, *Chairman.* L. F. RONDINELLA,
FRANCIS LECLERE, E. S. CRAWLEY.

Adopted February 5, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

THE NEW MAUSOLEUM COMPANY'S SYSTEM OF SANITARY ENTOMBMENT.

[*Report of the Committee on Science and the Arts.*]

[No. 1,502.] HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, February 5, 1890.

The Sub-Committee of the Committee on Science and the Arts, constituted by the FRANKLIN INSTITUTE of the State of Pennsylvania, to whom was referred, for examination,

THE SYSTEM OF SANITARY ENTOMBMENT,

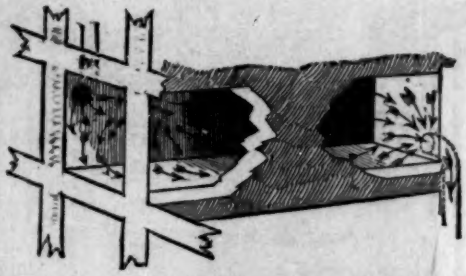
invented by John G. Meyers, of Washington, D. C., respectfully

Report that: They have examined the plans submitted to them and inspected the tests made by desiccating several human bodies and find as follows:

That the system depends for its operation upon the

enclosing of bodies in receptacles, or sarcophagi, made of concrete, and circulating pure, dry air through such receptacles; the air, entering at the head and passing lengthwise, is discharged at the foot into a closed conduit leading to a furnace in the annex building, where, after passing through the burning fuel, it is divested of all noxious or offensive properties and discharged through the chimney.

The plans of the invention embrace the construction of large buildings (*see accompanying plate*) having several floors and ample corridors, with tiers of sarcophagi of concrete, each provided with the proper air-inlet, separate from the ventilation of the building, and proper draft apertures leading to ample conduits for air, securing ample circulation



Single Casket Space or Cell, showing Inlet and Outlet Ducts for Air.

of dry air around each body, without the possibility of contamination from the gases or odors emanating therefrom.

The specimens submitted to the examination of the Committee had been exposed to drying currents of pure air for terms varying from four to eight months, and the features showed but slight evidence of distortion or decay, but simply of drying up of moisture and corresponding reduction in weight, and were all in far more presentable condition than any of dried or embalmed bodies which have been exhumed from ancient sepulchres.

The means of procuring dry air are simple and inexpensive; for small operations, passing the air over strata of dry chloride of calcium is the most ready, whilst for larger operations passing it over sulphuric acid is preferable, because the acid, after using, can easily be transferred by pumps to reservoirs and then, deprived of its acquired

moisture by heat, returned for repeated use, avoiding the unpleasant work of handling the pulverulent lime salt.

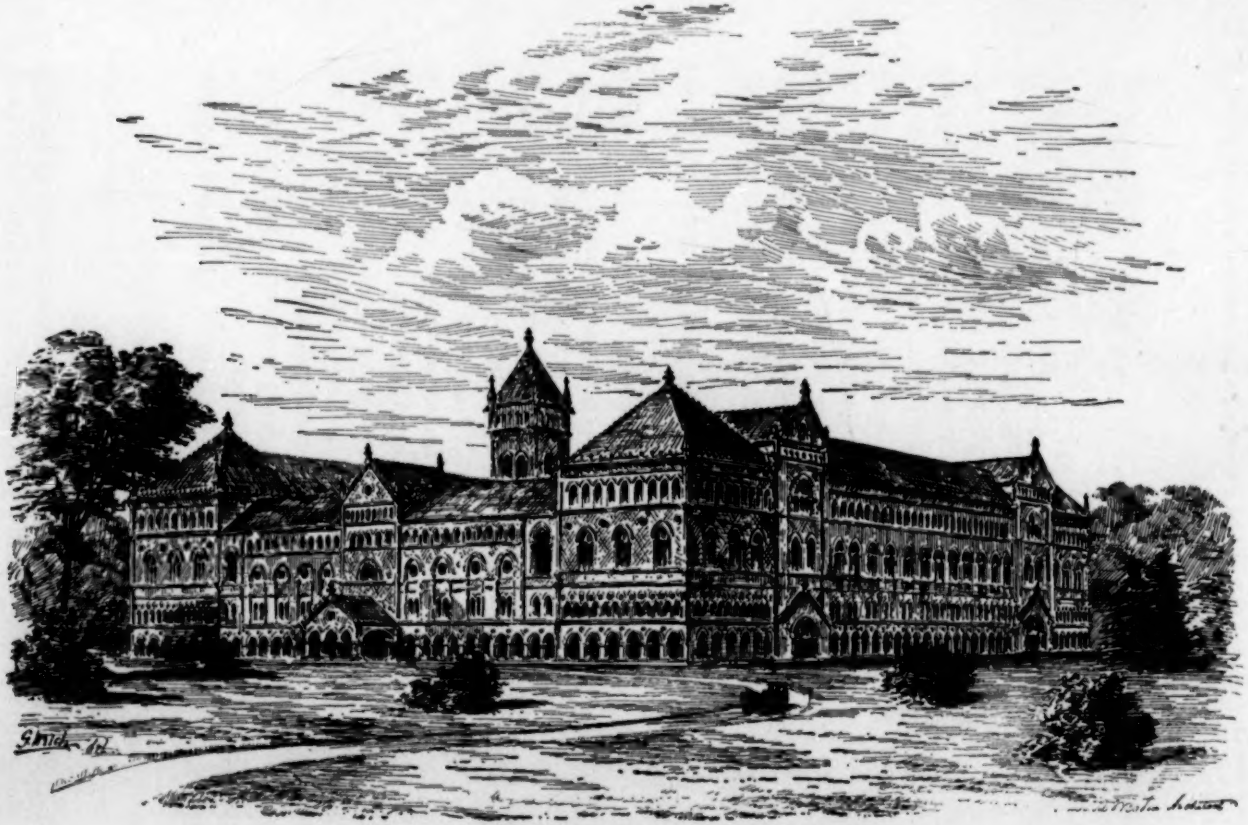
The air, it should be understood, is dried before entering the sarcophagi and does not again mingle with the atmosphere until it has passed through burning fuel.

During a portion of the several periods of experimental desiccation above referred to, common air was passed

Interior View.—From a Design of a Mausoleum to be erected in New York. (A Family Compartment.)

through the temporary sepulchres, resulting in the demonstration that, with the passing of undried air through the sealed concrete sepulchre, perfectly sanitary results are attainable, but that, the prevention of decomposition in the sepulchre by anhydrous air makes its use preferable.

The system appears to your Committee to possess the following advantages over sepulture or cremation:



Design of a Mausoleum to be erected in New York.

It defends the living effectually from contamination from the dead, either directly through the atmosphere or indirectly by pollution of either the earth or water.

It affords protection from suffocation, by premature interment, of living persons only apparently dead.

It secures the dead from theft.

It does not involve the exposure of the living to inclement weather in funeral ceremonies.

It preserves most effectually all evidences that could be demanded for medico-legal purposes.

It avoids every repugnant feature of mutilation for preservation of bodies, of cremation, and of sepulture in exposing the dead to the ravages of animals, worms and insects.

It secures as prolonged preservation for the dead as is desirable and, so far as human devices can make it sure, provides perpetual protection for them.

In point of cost, it is far less expensive than any other known sanitary and decent disposition of the dead.

Far less land is required for the same number.

No deterioration in the value of adjacent lands is produced by it.

No pollution of water courses and lands contiguous thereto can occur from it.

It does not, to your Committee, appear open to any other objection, than that it may, if extensively introduced, impair the profits of cemetery companies and their promoters; and it is, in the judgment of your Committee, not only entirely unobjectionable, but in every way desirable and commendable, and of first importance to every community, and as such deserves the recognition and approval of the FRANKLIN INSTITUTE by the recommendation of the award of the JOHN SCOTT LEGACY PREMIUM AND MEDAL.

S. LLOYD WIEGAND, *Chm.*,
L. L. CHENEY,
WILLIAM H. WAHL,
RUDOLPH H. HERING,
CHAS. E. RONALDSON,
RICHARD D. BAKER.

Adopted, March 5, 1890.

H. W. SPANGLER,
Chairman of the Committee on Science and the Arts.

ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

BY JOSEPH M. WILSON, A.M., C.E.
President of the FRANKLIN INSTITUTE.

[*Continued from vol. cxxix, p. 230.*]

L'ÉCOLE PROFESSIONELLE "IMPRIMERIE CHAIX."

The professional school of young printers, "L'Imprimerie Chaix" (Imprimerie et Librairie centrales des Chemins de fer) was founded in 1863 by M. Napoléon Chaix, its object being to form workmen, foremen and employés for the different departments of printing.

The founder aims to carry out his purpose, (1) by teaching methodically a professional employment; (2) by teaching elementary, special and technical courses; (3) by popularizing principles of saving and economy by the aid of savings-banks and pensions, by assuring in cases of accident or death, and by the sharing of profits. The school is under the immediate direction of M. Chaix, who is represented for all questions of teaching and administration in general, by M. Gustave Berger, "chef du personnel."

The school comprises two groups:

(1) Compositors and lithographers.

(2) Printers and boys in various services (ruling, stitching, making paper matrices, casting, stereotyping, office work), embracing the various branches of typographic industry represented in the establishment.

A large number of graduates have gone out from this school, the most of them being occupied in the establish-

ment of M. Chaix as workmen, employés in the office and as foremen. Some are employed outside, and have found advantageous engagements with other printing establishments, owing to the solid education which they have received in this school.

Students are received first only on trial, and they must not be less than thirteen years of age. They must be presented by their parents or guardians, and each one must show his certificate of birth, a certificate of primary elementary instruction signed by the Mayor, a pamphlet as prescribed by law (details not known), and a certificate of freedom from all engagements if he has been already working with any other establishment.

On entering, the pupil must submit to an examination to test the primary instruction which he has received; it is then designed to follow by that course in the establishment which conforms best to his degree of instruction. For compositors and lithographers, the examination, which is a competition, takes place every year in the last fortnight of August.

Before he can be admitted, the boy undergoes a medical examination, the result of which must show that he is in good health, has been vaccinated, and has no infirmity which would prevent him from properly undertaking his proposed profession.

After the first two months of trial, as required by law, the apprentice, if his aptitude is considered sufficient, is placed in that service which is most in accordance with his taste and capacity, and the parents or guardians are obliged to sign a contract of apprenticeship, the duration of which does not include the time of trial.

The student-compositors and lithographers are under a regular contract for an apprenticeship of four years, and the apprentice-printers and the boys of annexed departments, in number sufficient to assure the execution of all the work, are equally attached to the establishment by special agreement made with the parents for three or four years, after which they are guaranteed employment on presswork, in

making paper-matrices, stereotyping or ruling. Boys in the office, after their apprenticeship is over, are utilized in some of the departments according to their capacity.

The establishment does not provide lodging or board for the apprentices; they can live at home or in default of that, in a special *pension* provided for them. As a rule they bring their breakfasts to the school and are furnished with means for warming food if they wish to do so. If the breakfast be insufficient, or of bad quality, the establishment adds an additional quantity or replaces the bad by more healthy food. An exception to the rule is made with children whose parents reside in the immediate vicinity and these are allowed to take their breakfasts at home.

During their presence at the work-shops, including times for breakfast and recreation, a constant surveillance is exercised over the apprentices, both inside and outside the buildings.

A hygienic inspection, to which all of the apprentices must attend, is held each month by the physician attached to the establishment and this is independent of any ordinary consultation.

The apprentices have an interest in the perquisites of the establishment in proportion to the lengths of time that they have been apprenticed and to the work produced by them. The perquisites are fixed every month by M. Chaix with the advice of the foreman and employés in charge of the departments, on the following basis:

STUDENT COMPOSITORS AND LITHOGRAPHERS.

	Francs.
(1) After six months' trial,	0·75
(2) During the course of the second year,	1·00
(3) During the course of the third year,	1·50
(4) During the course of the fourth year,	2·00

BOYS WORKING MACHINES.

	Francs.
(1) During the period of trial,	0·75
(2) After four months,	1·00
(3) After eight months,	1·25
(4) After one year,	1·50

and so on, by proportionate increase, every four months until the end of the apprenticeship.

The apprentices have no other work than that of their special department of trade and they do not take special courses. They do not work on Sundays or holidays, and work practically ceases on Saturdays at four or five in the afternoon according to the season. Those under sixteen years of age are not allowed to sit up at night.

A committee, presided over by M. Chaix and composed of the "chefs de service" of the establishment, the foreman and the professors, meets every month to take into consideration measures in the interest of the boys and suggestions for improvement in matters of discipline, methods of teaching and the general direction of the school.

A note or memorandum-book is assigned to each apprentice and in this notes are kept of his work and conduct, which he is allowed to verify each month. From these books the parents may obtain detailed information as to the habits, conduct and standing of the boys, of the rewards which they have gained, and the perquisites which they have lost. The system at the same time operates for the general good of the school.

These books also contain information in reference to state institutions, particulars in favor of the working classes and statements as to the monthly and annual condition of the various insurance and savings departments of the establishment.

At the expiration of his apprenticeship the book containing the record of the graduate becomes his property and constitutes for him, when he has conducted himself well, the best certificate he can produce, if he leaves the establishment, to gain the confidence of his new patron and to testify as to his capability. During the period of trial a monthly bulletin takes the place of the record-book.

Independent of the general conditions as stated, the organization of the school also includes provisions for professional instruction under the following heads:

Practical work (compositors and printers).

Primary and technical courses.

Methods of encouragement and emulation.

Precepts in relation to deportment and discipline.

Practical work is divided into several departments. That for compositors is confided to a foreman aided by an assistant and a corrector. A special building is used for this department, entirely distinct from the other workshops, arranged to serve as a class-room as well as an atelier and furnished with all materials necessary to the work.

Notwithstanding that the apprentices have but little to do with the regular workmen, yet they are associated with them in their life and are occupied like them in the ordinary employments of the establishment. Their work is arranged, however, so that while adapted to their strength and age, it gives to them during their apprenticeship a complete course in the trade and an experience in all of the difficulties necessary to be surmounted before one can become a good workman. The studies are arranged for the several years as follows:

First Year.—Exercises in setting up from a printed page, lining the letters; spacing; justification; distribution; knowledge and use of the different kinds of type, etc.

Second Year.—Setting up from manuscript; correction; first exercises at tablework.

Third Year.—Tablework; setting up of algebra and geometry; typographical difficulties, pictures, titles, announcements, etc.; first exercises with the case in Latin and Greek, English and German.

Fourth Year.—Miscellaneous work, borders, vignettes, etc.; imposing and inserting pages; setting up Latin and Greek, and English and German.

An exercise is required every month after a series of porgressive models arranged for each year and comprising in the four years all the difficulties of typography. Every three months, in each course of the four years, a composition is made, and on these are based the recompenses which are awarded at the annual distribution of prizes.

The department for lithographers and engravers is under the charge of a foreman, and progressive instruction is given in the current work according to the capability of the pupils.

As with the compositors, exercises are required every month, based on a progressive system: Each boy is

required to take one of the courses in design of the "Ville de Paris."

In the department of printers, the boys (feeders and pressmen) are placed in the gang of a conductor under the direction of a chief and an assistant of proofs. The work is distributed as follows:

"*Feeders*" (first and second years).—Attending machines and margining in white.

"*Margeurs*" (third and fourth years).—Dressing machines, feeding to points, aiding conductors in their duties and making ready for press.

"*Student-conductors.*"—After the termination of their apprenticeship, the most expert pressmen are placed for two years with the best conductors of the establishment, under the surveillance of the chief of proofs, to learn making ready for press and the operating of machines.

There are divers services, such as making paper-matrices stitching, spacing, stereotyping and office work in which the boys are trained under a chief or foreman, working with employés, and employed in such service as is in accordance with their particular department of trade.

The primary special and technical courses are arranged so that the boys at their homes can carry on and complete the courses of study, which they commenced at the primary schools, prosecuting them in that direction best adapted to aid them in learning their trade.

This work is in charge of employés of the establishment, former professors, for the special primary instruction, and of foremen for the technical instruction.

The courses are of two degrees, the first comprising special primary and technical instruction for student compositors and lithographers, and the second a lower order of instruction for the printers.

The course for the compositors and lithographers is arranged in two divisions, one being the complement of the other. The first division, which is a two years' course for students of the first and second years, comprises six lessons per week, of one hour each. The special primary instruction consists of reading with explanations; writing, three

kinds; French language and grammar; arithmetic and geometry in their application to typography; history of France (les grandes époques) and geography, commercial and industrial, principally as connected with printing; readings and conversations on the ordinary sciences and their applications; summary notions concerning provident and savings institutions, pension and insurance funds, etc. The technical instruction comprises, reading of manuscript, grammar in relation to typographic corrections, typography as to composition and material.

The second division, a two-years' course, for students of the third and fourth years, also provides for six lessons per week of one hour each. The complemental instruction comprises French literature (compendium of authors); history of printing in France and abroad; elements of physics and mechanics, principally in their connection with typography; hygiene in its bearing on industrial economy. The technical instruction comprises grammar (typographical), typography (following the course of the first and second years); the languages, Latin, Greek, English and German (general principles in reading and writing as applied to composition in these languages).

The course for printers and boys in divers services is in two divisions, each having five lessons per week of one hour per lesson, given in the evening after work-hours. In the course for pressmen (apprentices of the third and fourth years) the instruction comprises reading and writing; the French language; orthography and elements of grammar; history and geography; arithmetic, the metric system and some ideas on lines, surfaces and volumes; a course on printing and tools. The course of arithmetic includes some notions on mechanics as applied to typographic machines, to organs of movement, to transmissions, etc., and some ideas on provident, savings and insurance organizations. The course for feeders (apprentices of the first and second years) comprise primary elementary instructions in reading, writing, elements of the French language, calculation (the four rules and the metric system), history of France and general geography.

In order to still further complete the instruction of the apprentice, and at the same time furnish useful diversion, a library is provided and placed at his disposal, comprising the best works on printing and various other industries, the lives of great men, history, travels and instructive and moral works of fiction. In a register kept for the purpose, each student using books, is credited with the titles of the books taken out, and when a volume is returned, he must, before receiving another, give an account of his reading and show that the subject is understood by him.

To encourage the students and to stimulate their zeal and desire for emulation in their practical and theoretical work, the following means are employed:

(1) Reading out in the school and workshops every month the marks earned by each scholar, the encouragements given to those who deserve them, and the demerits to those whose conduct and work require them.

(2) A monthly inscription of the names on a "tableau d'honneur" in accordance with notes kept of the work and conduct of each scholar in the workshop and school.

(3) Quarterly compositions in each faculty and for practical work, with a classification and inscription on a "tableau d'honneur."

(4) Successive augmentation of the daily perquisites, acting under the advice of the foremen and professors.

(5) Tokens of presence having a value of ten centimes each, given to each scholar whose work and deportment has been satisfactory during the course. It may be interesting to mention that these tokens have inscribed upon them a moral quotation from Franklin. The value of these tokens is paid to the scholar at the end of each month, and M. Chaix engages with the parents that their children shall be allowed to dispose of this little sum as they choose themselves. The total value of tokens distributed, from 1867 to 1888, was 19,559·50 francs, or an average of 931 francs per annum, being a mean of ten francs to each compositor and nine francs to each printer.

(6) Cash interests accorded to the student-compositors, in the profits realized by the establishment on the work

which they have carried out, a part proportional to their work and their deportment. The sums so set apart by the house since its creation have amounted to 21,390 francs.

(7) Monthly nominations of sergeants, chosen from among the apprentice-compositors and the boys attending machines, and appointed to assist the foremen and professors in their surveillance, to insure cleanliness and order in the workshops, to prepare the classes for the different courses, etc. A gift of a dozen photographs, or a perquisite of five francs, is given to the students who show proof of their zeal in carrying out these duties.

(8) Exceptional recompenses, such as books and various other articles, given on the 1st of January each year.

(9) A general distribution of prizes in the month of August: diplomas of honor, medals, books, etc. On this occasion reports are made to the students and graduates as to the condition of the various provident departments connected with the establishment, pensions, insurances, interests, savings-banks, etc.

In order to unite the old and new students in common sentiments of fellowship and responsibility, M. Chaix invites those apprentices who have already become workmen, to assist in the reunion, and every year exceptional rewards are bestowed on those who most distinguish themselves by assiduity in work, by regularity of conduct and deportment, and by the practice of saving and economy.

(10) In 1880, a medal was engraved as a perpetual souvenir of the school, with an inscription on one face and a figure of Guttenberg (after the Guttenberg of Calmels) on the other. Copies of this medal in silver and bronze are given at the general distribution of prizes, to those students who have obtained the "prix d'honneur," and to those "ancient apprentices" who have distinguished themselves most by their aptitude and by the services which they have rendered to the establishment.

In reference to the "discipline of the school" the following remarks may be made:

During work, the student-compositors must keep to their places and not talk or walk about except for the require-

ments of the service. One is selected each morning to do the necessary running through the establishment, and the others are not allowed to leave without authorization from the foreman.

The feeders and pressmen must remain at their machines and verify by the printed sheets that the correct working is kept up without raising of the letters or defects of any kind. During the making ready for press, they must hold themselves at the disposition of the conductors or clean their machines and conform themselves to the regulations against accidents. No feeder or pressman is allowed to quit his machine without the order of the conductor; playing is positively prohibited around the presses, even when they are not in action.

A daily record of presence is kept by the foreman, each student receiving a mark for his work and conduct, and note is made of all cases of lateness or absence, punishments inflicted, as well as the nature of the work done by each one. Every morning this record, with proofs of the work, for the compositors, is sent to the "chef de service," who values the work and conduct and gives to each student a mark varying from zero to ten. From these marks the monthly classification is made out.

At times of recreation the boys are put under the surveillance of an employé of the house and the foreman. In order to enable a better watch to be kept over them, they are obliged to play in the court of the printing-house or in the streets adjacent. All boisterous play, smoking and visiting of wine or tobacco shops, are strictly prohibited.

The means of discipline adopted are as follows:

(1) A reprimand; (2) a fine; (3) deprivation from recreation, with work in the shop or in the office of the "chef de service;" (4) deprivation of two hours' holiday on Saturday; (5) redistribution of type in the large shop after it has been knocked into pi; (6) total or partial deprivation of the daily perquisites; (7) public reprimand by the "chef de service;" (8) keeping on the feet for one or two days; (9) deprivation of a share in the dividends; (10) reprimand in the office of M. Chaix; (11) suspension for a limited time; (12) definite dismissal, with or without a certificate of discharge.

It will be noticed that, in France, boys do not appear to be allowed the same freedom of action that they have in this country or England; that they are always under surveillance, whether at work or play, and that no confidence or reliance is placed upon their honor as to obedience of rules or propriety of behavior. It would seem, as a natural consequence, that such a course would result in many of them growing up without that manly, independent, self-reliant spirit, so characteristic of our own boys, and that, even as men, they would always require a strong power to keep them in check, not being guarded by their own inward conscience and manliness from doing evil, but only by the feeling that they are being watched and may be detected. The custom is one that has been established for years, and it has ingrafted its effects on the nation, stamping on the people certain characteristics which it would be very difficult to eradicate.

Much might be said concerning the provident institutions connected with the establishment of M. Chaix, which are intended to secure to each pupil, at the expense of the house, a sum as a first savings or starting capital, and at the same time teach the principles governing the State Provident Institutions, so as to develop such moral qualities in the apprentice as will make him in the future a steady, prudent and industrious workman.

These provident institutions comprise, an academic savings-fund, a pension fund, insurance fund for cases of accident or death, a fund for participation in profits and a free savings-bank where the voluntary savings of the old apprentices may be deposited at interest.

The theoretical instruction of this department is divided into two courses, one upon questions of foresight, saving and the working institutions, and the other upon the first principles of industrial and social economy.

The practical instruction has for its ground-work a call for constant, and, so to speak, daily savings, which the establishment keeps before the apprentices first by gifts and annual encouragements, second by frequent counsels on the utility of saving and economy, third in assuring each month

and each quarter, without inconvenience to those interested, the payments to the state banks of the sums economized, and fourth, in confiding to the bank of the establishment the duty of collecting the savings.

LAWS OF FRANCE OF PUBLIC INSTRUCTION.

The laws of France relative to public instruction were thoroughly revised in 1880 to 1882, and are in very complete shape. It is neither necessary nor advisable to attempt a *verbatim* statement of them in this paper, but a free translation will be given, explaining the organization of the Department of Public Instruction as framed under these laws, and such other particulars as believed to be of interest in connection with the general subject under consideration.

The laws provide for a "Conseil supérieur," and "Conseils académiques," the members of which in each case are elected or appointed under certain regulations.

In the "Conseil supérieur" all the members are appointed for four years, and their powers can be indefinitely extended.

Nine members of the "Conseil" appointed by decree of the President of the Republic, and six designated by the Minister from among those elected, constitute a "permanent section." This permanent section has for its functions the consideration of all questions of study, administration and discipline; the creation of faculties, lyceums, colleges or schools; the suppression of chairs or courses of instruction; the arrangement of programmes, methods of study or regulations of administration; the overseeing of the schools, selection of books of study, and the consideration of questions of admission of strangers to teach in the schools, etc.

The "Conseil supérieur" is a council of appeal and of last resort on judgments rendered by the "Conseils académiques." There is a general meeting of the "Conseil" twice a year, but extra sessions can be held at the call of the Minister who is President of the "Conseil."

A "Conseil académique" is instituted at the chief place of each Academy. These "Conseils" give attention to the

regulations concerning the commercial colleges, the lyceums and sciences generally; to the organization of methods of superior public instruction; to the receipts and expenditures and other administrative accounts of the various establishments, and to all questions of administration and of discipline that are referred to them by the Minister of Public Instruction. They make reports each year to the Minister on the secondary and superior schools of public instruction and suggest any improvements which in their opinion might be introduced with advantage. Questions of discipline and teaching are decided by them, subject to appeal to the "Conseil supérieur," which must be made within fifteen days from the formal notification, but the "Conseil académique" can in every case order the provisional carrying out of its decisions, notwithstanding the appeal.

The Minister can reprimand any member of public instruction before the "Conseil académique" or censure him before the "Conseil supérieur" and no appeal can be made. He can also direct a change of a teacher in a superior school to an inferior employment, upon the advice of the "Conseil supérieur," or the same concerning a teacher in a secondary school, after having taken the advice of the permanent section. The Minister can pronounce a suspension for a time, not exceeding one year, without deprivation of salary; suspension for a longer time, with total or partial deprivation of salary, cannot be pronounced, except by the "Conseil académique," or, on appeal, by the "Conseil supérieur."

The "Counseil académique" also meets twice a year in ordinary session and can be convened in extra session by the Minister.

There is a Consulting Committee on Public Instruction, which is divided into three sections, corresponding to the three orders of teaching, superior, secondary and primary, the members forming these sections being selected by the Minister for one year from among the general inspectors, honorary professors, professors, teachers, etc., in accordance with certain regulations, and these appointments can be extended. Each section has for Secretary a "chef de bureau" of the central administration.

The section on superior instruction is divided into five committees, namely: Academic, law, medicine and pharmacy, science and letters.

The academic committee considers all questions of "scolarite" not referred to the permanent section. The four other committees give their opinions on any suggestions for improvements which may be made by the different academies; on the programmes of the various courses; on the value of the theses and work of candidates for degrees; also, on questions of increase of salary. The committees on science and letters study the monthly reports of the deans on conferring the degree of licentiate and on preparation by correspondence. These two committees and that of medicine and pharmacy, arrange the lists, by order of merit, of the candidates to scholarships of superior instruction.

The section on secondary instruction deliberates on all questions relative to personnel and to promotions, which are submitted to it by the Minister.

The section on primary instruction gives its opinion on demands made by establishments of free primary education concerning subsidies, authorizations for state scholarships, etc.; on the progress of studies in the normal schools; on examination theses of different grades; on exemptions on account of age; on the promotion of officers and on all questions which may be submitted to it by the Minister.

The laws provide that schools shall be founded by the state for the secondary instruction of young girls, with the concurrence of the departments and communes. These establishments are to be day-schools, but boarding-schools may also be provided as annexes, on demand of the municipal authorities, after an understanding with the state, and they are subject to the same *régime* as the communal colleges.

Scholarships for the benefit of the boarders and half-boarders, as well for pupils as pupil teachers, shall be founded where the establishment is created by the state, the departments and the communes, the number of them to be

determined in the constitutive agreement made between the departments, communes and the Minister.

The course in these secondary schools comprises: Moral instruction, the French language, reading aloud and at least one living language; ancient and modern literature; geography and cosmography; natural history and a glance at general history; arithmetic, the elements of geometry, of chemistry and of natural history; hygiene; domestic economy; work with the needle; notions of common law; drawing; music; gymnastics.

Religious instruction is provided at the request of the parents, to be given by such ministers of the various creeds as approved of by the Minister of Public Instruction. The ministers are not allowed to reside in the school and the teaching is given in the school, but out of class-hours.

A course of pedagogy can be attached to establishments of secondary instruction. No pupil can be admitted into a secondary school without an examination to establish her ability to undertake the work, and a diploma is awarded after graduation. Each establishment is governed by a directress, and the instruction is given by male or female teachers who have had regular diplomas.

The course of secondary instructions for young girls requires five years, and it is divided into two periods of three and two years respectively, the courses in the first being all obligatory, but in the second only a certain number, the others being optional. The distribution of the subjects of instruction is fixed by a ministerial decision after advice with the "Conseil supérieur." At the end of each school year each student must submit to an examination to pass into the superior class, the examination after the third year permitting the conferring of a certificate of secondary study. The diploma at the end of the secondary studies is given after an examination on the obligatory studies of the two last years and also on such optional studies as were assigned to the student.

In June, 1881, instruction was made absolutely gratuitous in the primary and infant schools, and also in the normal primaries.

Concerning the law on primary obligatory instruction, the teaching comprises: Moral and civil instruction, reading and writing, the language and elements of French literature, geography, particularly that of France; history, especially that of France up to the present time; some notions of common law and political economy, the elements of the natural sciences, physics and mathematics, their applications to agriculture, hygiene and the industrial arts, manual training and use of tools of the principal trades, the elements of drawing, modelling and music, gymnastics, military exercises for the boys and work with the needle for the girls. The primary public schools have holiday one day in the week, and also on Sunday, in order to allow the parents, if they wish, to give religious instruction to their children outside of the school buildings. Religious instruction is optional in the private schools.

Primary instruction is obligatory for children of both sexes, from the age of six years completed to the end of the thirteenth year; and this instruction may be given either in the primary or secondary schools, or in the public or free schools, or in the family by the father himself or by any other person he shall choose.

There is a law to determine the means of insuring primary instruction to deaf and dumb and blind children.

A municipal scholastic commission is instituted in each commune to overlook and encourage the frequentation of schools. This is composed of the Mayor as President, of a delegate from the canton (and in the communes comprising several cantons, as many delegates as there are cantons), designated by the Inspector of the academy; of members named by the municipal council in equal number, or at least a third of the number of this council.

In Paris and Lyons, there is a commission for each municipal arrondissement. The commission in Paris is presided over by the Mayor, and in Lyons by one of the assistants; it is composed of a cantonal delegate designated by the Inspector of the academy, and of members designated by the municipal council, in number from three to seven for each arrondissement. The official tenure of the members of

the scholastic commission lasts until the election of a new municipal council, and it is always renewable.

A certificate of primary studies is granted for children of eleven years of age, after a public examination. Those over that age receiving this certificate are relieved of any further scholastic requirements.

The parent, or whoever represents the child, must notify the Mayor at least fifteen days before the commencement of the school term, whether he intends to have the child instructed at home, or in a public or private school, and if in a school, he must indicate his particular choice of school. Where several schools are in the neighborhood, he has the right of selection, whether in his commune or not, provided the school he selects has not already received its maximum number.

Each year the Mayor prepares a list of all the children in in his department whose ages are between six and thirteen years, and notifies the parents or guardians of the time of the re-opening of the schools. If any one neglects to enroll a child after such notification, the Mayor attends to the matter himself. Eight days before the schools are re-opened, he sends lists of the scholars to each school and duplicates to the primary inspector.

When a child quits a school, the parent or person responsible must give immediate notice of the fact to the Mayor, and state how it is desired that the child shall be instructed in the future.

In cases of occasional absence of the pupil, the parent, or guardian, must give a reasonable excuse. Each month the director or directess must furnish to the Mayor a list of all absences with the excuses, which are submitted to the scholastic commission for approval. The only valid excuses are the following:

Sickness of the child, death of a member of the family, accidental difficulties of communication, or other exceptional circumstances at the discretion of the committee.

Any director of a private school who does not conform to the laws, is referred to the departmental council, which can pronounce the following punishment:

(1) A warning; (2) a censure; (3) a suspension for a month or more; and in case of a second offence in the year, a still further suspension of three months.

When a child absents itself from school as often as four times in a month and at least one-half day each time, without proper excuse, the parent or guardian is given notice, with at least three days' grace, to appear before the commission, which will remind him of the law and explain his duty. If he fails to obey the notification without giving sufficient reason, he can be punished.

In case of a repetition of the offence within twelve months, the commission posts the full name and position of the offending party on the door of the Mayor's office with a statement of his transgression. A renewal of the offence is considered an infraction of the law and brings the matter before the justices of the peace, the offender being punishable under the penal code.

The scholastic commission can accord to children living with their parents or tutors, when they give a proper reason, a dispensation from attending school, but it must not be over three months in the year in addition to vacations, and if the exemptions exceed fifteen days, should be submitted for the approbation of the primary inspector.

These rules are not applicable to children who accompany their parents or tutors during temporary absence from home, and in this case a verbal or written notice to the Mayor or instructor, will be sufficient. The commission can also, with the approbation of the departmental council, excuse children employed in industries and arrived at the age of apprenticeship, from one of the two sessions of the day, and the same privilege can be accorded to children employed in agriculture.

Children who are instructed at home, must at the end of the second year of obligatory instruction, submit to an examination in such studies, as children of corresponding age are taught in the public schools, following such programmes as are fixed by the ministerial decrees rendered in the "Conseil supérieur." The examination committee should be composed of the primary inspector or his delegate, as

President; a cantonal delegate, and a person who has a university diploma or a brevet of capacity. The judges are chosen by the Inspector of the academy, and in the examination of girls the one selected should be a woman.

If an examination is not satisfactory, and no excuse can be admitted for the child by the examination committee, the parents are obliged within eight days after notification, to send the child to a public or private school, and to inform the Mayor what school they select. If they do not attend to it the Mayor does it for them.

[*To be continued.*]

"WATER RAM" IN PIPES.

By Irving P. Church, Ithaca, N. Y.

The increased internal pressure occasioned by the more or less sudden closing of a valve gate in a pipe containing flowing water is a well-known phenomenon. In the writings of authorities on hydraulic engineering, it seems customary to make only a rough allowance for this source of danger to pipes, with but scanty show of rational basis for the rule given. In an issue of *Mechanics*, of August, 1884, Mr. Nystrom treats a somewhat similar case, where, in his analysis, use is made of the fact that the momentum of the water in the pipe at the initial instant of the operation of closing is completely exhausted at the end of that operation. Mr. Nystrom evidently assumes that the resistance met by the head of this mass of water is constant, so that his result gives only the average pressure due to the arrest of momentum (a time average). The danger in any such case, however, depends on the amount of the *maximum* pressure, which may be many times the mean and depends not on the time of closing merely but on the rate of motion of the gate, or valve, at different parts of the motion. For example, the motion of the gate may be so managed that the maximum pressure shall be much less than with some different management, the whole time of closing being the same in the two cases.

In the present paper the writer will attempt to trace the variation of the pressure just above the valve gate for certain definite cases, with numerical examples, and thus try to advance a stage further into the problem. The full treatment of the matter requires a knowledge of the hydraulic conditions *below* the valve gate as well as above it; and if these are not simple, complications arise, as will be indicated at the close of the paper.

To make the down-stream conditions as simple as possible, let us consider the case in *Fig. 1*, where the water in a long level pipe, with its inlet just below the reservoir surface at R, has a velocity of u_0 at the instant when a valve gate $A\ m$ begins to close the lower end, O, of the pipe, which discharges into the air. [We are not concerned with the possibility of generating this velocity under the conditions

FIG. 1.

assumed, which are necessary to secure exact mathematical treatment. That is to say, we consider the effect of the valve gate in checking the momentum of the water in the pipe without regard (for the present at least) to the static head behind the latter at R. This is a feature of Mr. Nystrom's treatment, as well.]

The gate descends progressively, decreasing the area F of the orifice of discharge $m\ O$. The velocity u in the pipe decreases, while that, v, of the *jet* (as we may call it) $O\ W$, increases, its initial value having been u_0. The fluid pressure p (per unit area) in the plane $n\ r$ just back of the orifice begins to increase from its initial value which was one atmosphere. We wish to find the maximum value of p, occurring, as it may, at any instant during the time t_0 occupied by the lower edge of the gate in passing from A to

O; *i. e.*, t_0 is the whole time of closing. It is plain that we shall need to know not only the whole time of closing but also the *law of closing*; that is, a relation between the area F, at any instant and the time t which has elapsed since m left position A. Let us first assume, then, that the closing is *uniform*, equal reductions of area of orifice occurring in equal times; *i. e.*, let us put the two ratios equal

$$\frac{F}{F_0} = \frac{t_0 - t}{t_0} \qquad \text{(uniform closing)} \qquad (1)$$

(Strictly F is the area of section of the contracted vein, and will be so treated finally; for the present, to secure clearness in the figure, we neglect contraction.) F_0 is the constant sectional area of the pipe.

As regards the dynamic conditions of the mass $n\ R$ of water in the pipe, at any instant, its horizontal acceleration may be expressed as $\frac{du}{dt}$, its mass is $\frac{Fl\gamma}{g}$, (γ being the weight of a unit volume of water) the horizontal resisting force at $n\ r$ is $F_0\ p$, while there is a forward horizontal force $= F_0\ p_a$ (very nearly) at R (with p_a to denote atmospheric pressure). As an error on the safe side we shall neglect fluid friction on the inside wall of pipe, especially as it decreases rapidly with diminishing velocity. Hence, from

Force = mass × accel., we have $-F_0(p - p_a) = \frac{F_0 l\gamma}{g} \cdot \frac{du}{dt}$;

and finally—

$$\frac{du}{dt} = -\frac{g}{l} \cdot \frac{p - p_a}{\gamma} \qquad (2)$$

(l is the length of the pipe.)

The plane $n\ r$ may be looked upon as the face of the piston of a force pump forcing water through an orifice $m\ O$ in the end of a pump cylinder; that is, the flow may be considered to be steady for the instant through the short distance $r \ldots O$; which gives (from Bernoulli's principle)—

$$\frac{p - p_a}{\gamma} = \frac{v^2}{2g} - \frac{u^2}{2g} \qquad (3)$$

Substituting from (3) in (2), dividing throughout by u^2,

multiplying by $d\,t$, and remembering that we have $F\,v = F_0 u$,

$$2\,l\,.\,\frac{d\,u}{u^2} = -\left[\frac{F_0^2\,d\,t}{F^2} - d\,t\right] \tag{4}$$

In (4) the separation of the variables has been effected except that it remains to express F in terms of t, for which with *uniform closing* we use eq. (1); whence, appending the integral sign, with the *upper limits variable*—

$$2\,l \int_{u_0}^{u} \frac{d\,u}{u^2} = -\,t_0^2 \int_{0}^{t} \frac{d\,t}{(t_0 - t)^2} + \int_{0}^{t} d\,t \tag{5}$$

This is easily integrated, remembering that $d\,t$ is the same thing as $-\,d\,(t_0 - t)$; whence, integrating and putting in the limits and reducing, we have—

$$2\,l\left(\frac{1}{u} - \frac{1}{u_0}\right) = \frac{t^2}{t_0 - t} \tag{6}$$

By the aid of eq. (1), we now eliminate t from (6), and obtain—

$$2\,l\left(\frac{1}{u} - \frac{1}{u_0}\right) = \frac{t_0}{F_0\,F}\,(F_0 - F)^2, \tag{7}$$

giving a relation between the two variables u and F.

We may solve (7) for u, and insert the value found in the relation $F_0\,u = F\,v$, whence finally, after writing x for $\frac{F}{F_0}$ for brevity, we have—

$$v = \frac{u_0}{x + \frac{u_0\,t_0}{2\,l}\,(1 - x)^2}\,; \tag{8}$$

a relation between the variables v and x. Also, from $F_0\,u = F\,v$ and eq. (3), we have—

$$u = x\,v \tag{9}$$

and

$$\frac{p - p_a}{\gamma} = \frac{v^2 - u^2}{2\,g} \tag{10}$$

Since $\frac{p - p_a}{\gamma}$ is the pressure head, or water height, measur-

ing the resultant bursting pressure due to pressure p, we can, for any assumed x (that is, at any assigned stage of the closing), compute the corresponding v from (8), then u from (9) and, finally, $\frac{p - p_a}{\gamma}$ from (10).

It is noteworthy that for $x = 0$, eq. (8), gives $v = \frac{2l}{t_0}$, which is *independent of* u_0; *i. e.*, in uniform closing the velocity of the jet just at the end of the closing is independent of the initial velocity of the water in the pipe. Hence, the bursting pressure p at this final instant is also independent of u_0, and is the maximum pressure occurring during the closing, when u_0 is small compared with $2l \div t_0$ (as will be seen). The value of the corresponding pressure head is $2l^2 \div g t_0^2$.

Example 1, Uniform Closing.—As a numerical example of "uniform closing," suppose the pipe to be $l = 10{,}000$ feet in length, the initial velocity of the water in it to be $u_0 = 6$ feet per second, and the time of closing to be 600 seconds $= t_0$. Assigning to x the successive values 1·00, 0·80, 0·70, etc.; that is, dividing the initial area of orifice into five equal parts, one of which is to be uniformly closed up every 120 seconds; the following values of the other quantities were obtained, from eqs. (8), (9) and (10):

x (Abs. No.)	v (Ft. per Sec.)	u (Ft. per Sec.)	$v^2 - u^2$	$\frac{p - p_a}{\gamma}$ (Feet.)	t (Sec.)
1·00	6·00	6·00	0·0	—	—
0·80	7·44	5·95	20·0	—	120
0·60	9·54	5·72	58·3	—	240
0·40	12·90	5·16	139·8	—	360
0·20	19·02	3·80	346·6	—	480
0·00	33·33	0·00	1089·0	16·9	600

From this table we note that the reduction of velocity u in the pipe is very slight during the first half of the time of closing, and is very rapid toward the close. The increase of effective bursting pressure $(p - p_a)$ (which is proportional to $v^2 - u^2$) is also gradual at first, but is extreme toward the close, where the value of $\frac{p - p_a}{\gamma}$ is a maximum, and is =

16·9 feet (indicating an effective pressure of about eight pounds per square inch).

The variation in u and $\frac{p - p_0}{\gamma}$ during the closing is shown by the corresponding curves ($a\,b'\,O$ and $A\,P\,M$) on the left, in *Fig. 2*, where the heavy lines marked (I) refer to this numerical example of uniform closing. $A\,O$ represents the full size of the pipe section, or $x = 1{\cdot}00$, $O\,..\,m$, the value of x at any stage of the closing. Horizontal abscissæ measured from O toward the right, represent the time t of reaching any stage, and $O\,V$ the whole time t_0 of closing.

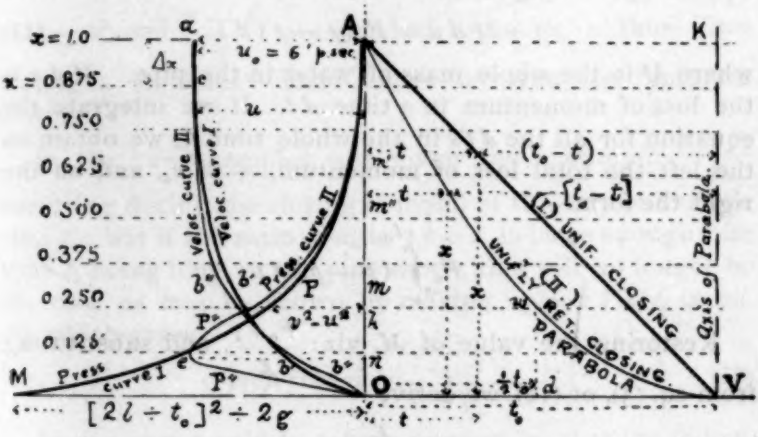


FIG. 2.

The straight line joining A with V corresponds to uniform closing, as it makes x proportional to $(t_0 - t)$. Laying off to the right from O any assigned time, t on the same scale by which $O\,..\,V$ denotes t_0, and raising a vertical, we draw a horizontal through the point in which the latter intersects $A\,..\,V$. The m' of this point shows the relative area ($F : F_0 = x = m'\,O$) of the orifice at the end of the time t. [If there were no contraction and the orifice were always rectangular, with constant width perpendicular to the paper, the point m' would indicate the corresponding position of the lower edge of the gate. For the present, this may be assumed to be so, for the clearer appreciation of the diagram.

Later, the actual position of the lower edge of the gate closing a circular pipe section, *without* ignoring contraction, will be indicated for any time t.]

Abscissæ have been laid off to scale toward the left from $A \ldots O$ to show the variation in u and $\frac{p - p_a}{\gamma}$; as already mentioned. Note "Veloc. Curve I" and "Press. Curve I."

As a proof of the correctness of the foregoing theory and its numerical results in the present example, the following may be noted: Now that eqs. (8) and (9) enable us to compute v and u for any value of x (and hence of t) note that the equation preceding (2) may be written—

$$-M\,du = F_0(p - p)\,dt \qquad (11)$$

where M is the whole mass of water in the pipe. $M\,du$ is the loss of momentum in a time dt. If we integrate the equation for all the dt's in the whole time t_0, we obtain on the left the total loss of momentum, $+ M u_0$, and on the right the form—

$$F_0 \int_0^{t_0} (p - p_a)\,dt.$$

Restoring the value of M, viz: $\frac{F_0 l \gamma}{g}$, and substituting from eq. (3), or (10), we derive—

$$2 l u_0 = \int_0^{t_0} (v^2 - u^2)\,dt \qquad (12)$$

In the numerical example just presented the value of $2 l u_0$ with the foot and second as units is 120,000. By laying off a horizontal line whose length represents 600 seconds, dividing it into five equal parts and erecting ordinates equal by scale to the respective values of $v^2 - u^2$ (in the table just given) at the points of division, we have a plane figure whose area represents the summation—

$$\int_0^{t_0} (v^2 - u^2)\,dt.$$

Applying Simpson's Rule to the approximate determination

of the area of the four strips between ordinates 20 and 1,089, and calling the first strip between the ordinates 0 and 20 a triangle, the number 121,528 is obtained.

Example 2, of "Uniform Closing." (Results not shown in any diagram.)—With a smaller initial velocity in the pipe, viz: $u_0 = 3$ feet, instead of 6, other data being the same as in the preceding example, plotted results show that large decrease in u is deferred till much nearer the end than in ex. 1, causing the velocity curve to drop with greater suddenness. The pressure curve has the same general appearance as in ex. 1. Its abscissæ increase faster, however, until at the end of the closing the same values for v, $v^2 - u^2$, and $\frac{p - p_a}{\gamma}$ are reached as in ex. 1, thus illustrating a statement made above as true for "uniform closing."

In the two examples just given the maximum $\frac{p - p_a}{\gamma}$ occurring during the closing is found at the very end of the time t_0; but if the ratio of u_0 to $2l \div t_0$ is large enough (the time t_0 being long, or the pipe short), this will no longer be the case, as may be shown by making $u_0 = 2l \div t_0$ in eq. (8), which gives

$$v \text{ proportional to } \frac{1}{x + (1 - x)^2} \qquad (13)$$

Such a case would be rare in practice, so that the following figures, computed from (13), are more curious than useful:

For $x =$	1·00	·80	·60	·40	·20	0·00
$u =$ Const. $\times$	1·00	·952	·786	·524	·238	0·00
$v^2 - u^2 =$ Const. $\times$	0·00	·50	1·09	1·44	1·35	1·00

Evidently—

$$v^2 - u^2, \left(\text{and consequently } \frac{p - p_a}{\gamma}\right),$$

is a maximum for $x =$ about 0·40.

In this connection it is well to state that we have implicitly considered that the head of the pipe at R in *Fig. 1* is not so near the surface of the reservoir, but that a new

supply of water with velocity u is continually entering the pipe to take the place of the liquid leaving the pipe at O, thus enabling us to consider the mass of water in the pipe constant during the closing of the gate.

With

$$u_0 = 3\left(\frac{2l}{t_0}\right), \qquad \frac{p - p_0}{\gamma}$$

will be found to be a maximum for $x =$ about 0·60.

As to just what relation should hold between u_0 and $\frac{2l}{t_0}$ that the maximum pressure shall occur just short of the actual end of the closing (and thus be a maximum at that point in the sense used in calculus) the writer has not taken time to determine. It may not be far from—

$$u_0 = 0{\cdot}70\left(\frac{2l}{t_0}\right).$$

(To be continued.)

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, March 18, 1890.*]

HALL OF THE FRANKLIN INSTITUTE.
PHILADELPHIA, March 18, 1890.

In the absence of the President and Vice-Presidents, Dr. L. B. HALL was elected by the Section President *pro tem.*

Members present: Dr. H. W. Jayne, C. J. Semper, H. Pemberton, Jr., L. E. Williams, J. H. Eastwick, Prof. N. Wiley Thomas, Dr. S. C. Hooker, Reuben Haines, A. W. Allen, L. J. Matos, Philip S. Clarkson, Dr. L. I. Morris.

A letter from Dr. Wahl was read, in which he called the attention of the Section to the fact that at his suggestion the Library Committee had authorized the purchase of the complete set of Liebig's *Annalen*, from 1832 to 1886. He also recommended that the Section subscribe for this journal regularly, commencing with 1887. On motion, the Section voted that the Treasurer be authorized to continue the subscription, as suggested by Dr. Wahl.

The Treasurer called the attention of the Section to the very satisfactory condition of the treasury, and recommended that expenditures for additional journals, as well as standard works of reference, be made. On motion, the Section voted that a committee be appointed by the Chair to make selections of such journals or other works as might be purchased, the committee to report to the Section at a future meeting. The President appointed J. H. Eastwick, Dr. H. W. Jayne, Dr. S. C. Hooker and Dr. Wm. H. Wahl, members of this committee.

Dr. Hooker called the attention of the Section to some new developments in the work conducted by himself and Dr. Greene on lapachic acid and its derivatives. Certain points of difference in the views of the authors on the one hand and E. Paterno, on the other, concerning the structure of these bodies, were made clear in his remarks, which were listened to with much interest by the members.

Mr. Reuben Haines called the attention of the Section to Dr. Pruden's recently published work on Bacteriology. He discoursed at some length various points of general interest in the work.

Dr. L. B. Hall referred to an observation recently made by him of the

peculiar blue color which a mixture of sulphuric acid and phosphorus pentoxide assumes on standing for a time. The observation was made in connection with the application of Kjehldahl's method of determining nitrogen. None of the members present had ever noticed the phenomenon.

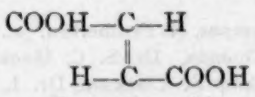
Adjourned. WM. C. DAY, *Secretary.*

ON THE SYNTHESIS OF FUMARIC ACID.

BY E. H. KEISER.

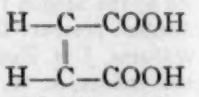
[*Read at the Stated Meeting of the Chemical Section, held February 20, 1890.*]
[*Preliminary Communication.*]

Van't Hoff * has proposed the following stereometric formulæ for fumaric and maleic acids:



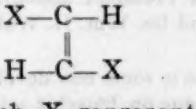
Fumaric acid.

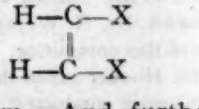
and



Maleic acid.

Johannes Wislicenus† has shown in a series of important papers that it is possible to determine experimentally the stereometric formulæ of certain isomeric compounds. A consideration of the hypothesis put forward by him suggested the idea that it ought to be possible to prepare both fumaric and maleic acids synthetically from acetylene. In accordance with Van't Hoff and Wislicenus' theory, the di-halogen additive compounds of acetylene can exist in two isomeric forms having the formulæ:

I. 

and II. 

in which X represents any halogen atom. And, further, compounds having the constitution represented by formula I are more stable than those having the structure represented by the second formula. Fumaric acid would then

* *Lagerung der Atome im Raume*, p. 21.

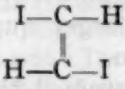
† *Räumliche Anordnung der Atome in organischen Molekulen. Ann. Chem.* (Liebig), **246**, 53.

appear to be closely related to the halogen derivatives of the first class, and maleic acid to those of the second.

It occurred to me that it mihgt, perhaps, be of interest in this connection to start with acetylene, and prepare, in the first place, two isomeric di-halogen additive compounds, and then endeavor to transform these into fumaric and maleic acid. The investigation is not yet completed, but one of the acids, namely, fumaric acid, has been prepared in this way from acetylene.

Acetylene was prepared by the action of alcoholic potash upon ethylene bromide, and the purified gas was passed through a series of wash-bottles containing crystals of iodine covered with a layer of absolute alcohol. After a time, the iodine disappeared, and from the liquid two isomeric acetylene di-iodides were separated. One of these compounds is a solid at ordinary temperatures; the other is a liquid. The solid di-iodide is much more stable than the liquid variety. It does not decompose on standing, and can be sublimed without suffering change. On the other hand, the liquid di-iodide undergoes decomposition when heated, and cannot be distilled with steam without being decomposed. These compounds have been prepared by Sabanejeff,* who has analyzed them and found them to have the composition represented by the formula $C_2H_2I_2$. No attempt was made by him to determine their constitution.

In accordance with the Van't Hoff hypothesis, the solid acetylene di-iodide, which is much more stable than the liquid di-iodide would have the constitution represented by the formula—



and would, therefore, belong to the same general class of acetylene derivatives to which fumaric acid belongs. Now, experiment shows that this solid acetylene di-iodide can be transformed into fumaric acid.

* *Ann. Chem.* (Liebig), **178,** 118.

Nine grams of the acetylene di-iodide crystals (m. p. 73°) were dissolved in alcohol, and five grams (two molecules) of potassium cyanide added, and the solution was boiled for thirty-six hours in a flask with an inverted condenser. Caustic potash was thereupon added, and the boiling continued for two hours longer. On cooling the contents of the flask a considerable quantity of needle-shaped crystals separated from the liquid. They were removed from the solution, and on examination proved to be the potassium salt of fumaric acid, which crystallizes in the form of needles, insoluble in cold alcohol. More of the salt was obtained from the mother-liquor. The aqueous solution of the potassium salt was treated with silver nitrate and a white precipitate consisting of the silver salt was obtained. The silver salt was purified by dissolving it in nitric acid and reprecipitating it by carefully neutralizing the solution with ammonia. The silver salt of fumaric acid is characterized by its great insolubility in water, and by the fact that when it is heated it deflagrates like gunpowder. Both of these properties were exhibited by the silver salt of the acid made by synthesis.

A quantitative determination of the percentage of silver gave the following result:

·2039 gram of the salt, dried at 100° gave
·1786 gram of Ag Cl = 65·97 per cent. Ag.

	Calculated for $Ag_2 C_4 H_2 O_4$.	*Found.*
Ag, ...	65·43	65·97

The free acid itself was recognized by its insolubility in water; it was precipitated from moderately concentrated solutions of its salt by the addition of strong acids. It will be analyzed as soon as larger quantities of it have been obtained in pure condition.

In 1882, Sabanejeff* studied the action of potassium cyanide upon acetylene di-bromide and obtained an acid having the formula $C_4H_6O_5$. It is probable that fumaric or maleic acid was first formed in his experiments, which afterwards, by the prolonged action of boiling caustic alkali, was

* *Ann. Chem.* (Liebig), **216**, 275.

converted into the acid $C_4H_6O_5$. It has been shown by Linnemann and Loydl* that when fumaric acid is heated with caustic alkalis, it is gradually changed into an inactive maleic acid, thus:

$$C_4H_4O_4 + H_2O = C_4H_6O_5$$

Fumaric acid. Inactive maleic acid.

A more detailed study of the reactions, which gives rise to the formation of the two acetylene di-iodides, as well as the attempt to prepare maleic acid from acetylene, is reserved for future work.

BRYN MAWR, PA., February, 1890.

NOTES AND COMMENTS.

CHEMISTRY.

NOTES FROM THE PARIS EXPOSITION OF 1889. By Prof. George Lunge—

Barium peroxide and hydrogen peroxide are acquiring a constantly increasing importance; woollen bleaching makes large use of them; the bleaching of feathers, of ivory, and of wild silk can hardly be done without them, and as they become cheaper, the range of their applications will certainly widen. These products were shown in Paris by a large number of exhibitors. One of the principal firms decomposes the barium peroxide with aqueous carbonic acid under pressure, and carries out the filtration from barium carbonate also under pressure. Another manufacturer uses hydrofluoric acid, for which, as a decomposing agent, he claims the best results. He commences with barium nitrate, which, in order to avoid the later swelling up, he fuses and then spreads out in shallow trays where it is changed into barium oxide and then into peroxide. He loses the nitric acid in this case, although that could be easily recovered. The change of oxide into peroxide takes place in a current of air, purified from moisture and carbon dioxide by passage through caustic potash, and drawn through by chimney draft. The change is completed in five to six hours. The barium peroxide is powdered, hydrated and decomposed by the hydrofluoric acid in a vessel cooled externally to a temperature of 15° C. The barium fluoride is used again for the manufacture of the hydrofluoric acid. The hydrogen peroxide is chiefly used in the bleaching of feathers, which requires twenty-four hours in a very slightly ammoniacal bath, repeated if necessary; for Tussah silks, which are not attacked at all, although barium peroxide robs them of their lustre; and for woollens which do not turn yellowish again. S. P. S.

Benzenes from Coke-Oven Gases.—The fact that coal tar has until recently been obtained only as a side product in the gas manufacture, has led to great

* *Ann. Chem.* (Liebig), **192**, 80.

fluctuations in its price, and so frequently disturbed the industries based upon its utilization. This condition has, however, changed notably in the last few years. In the first place, the production of tar (along with ammonia) in the coke manufacture furnishes additional raw material; in the second place, notable quantities of benzene, the most valuable constituent of the tar, are contained in the illuminating gas, and can be extracted from it. It is true this would diminish the illuminating power of the gas, and perhaps leave it only fit for fuel gas or for gas motors, so it has not been done to any extent hitherto. Now a new source appears in the gas which is given off from the coke ovens along with the tar and ammonia. This gas is already too poor in illuminating quality to be used for anything except heating the oven flues, raising steam, etc., so that in extracting the benzene from it we do not rob it of any constituent indispensable as an illuminant. The initiative in this utilization has been taken by Carvès, to whom we owe already the Simon-Carvès form of coke oven, one of the most practical forms for recovering the other residuals. His process is to withdraw the benzene from the coke-oven gases by passing them through heavy coal tar (boiling at about 200° C.), and then to distil off the benzene from the heavy solvent. The process is carried out already on a large scale in France, and products from this benzene were exhibited.

S. P. S.

Saponification of Fats.—DeMilly has solved the problem of making the aqueous saponification method a continuous and automatic one. The new autoclaves work at a pressure of fifteen atmospheres, that is at 200° C., the continuous agitation of the mixture of fat and water being effected by a stream of superheated steam, which, after it has heated and mixed the contents of the autoclave, issues from a spiral tube, the condensation water of which is automatically emptied. This spiral passes through a vessel containing glycerin water which is thereby concentrated to the 28° or 30° B., required by commerce. The steam which works in the autoclave is thus thoroughly utilized and moreover by its condensation continually draws forth steam from the boiler. There is no mechanical agitation of the contents of the autoclave necessary, as the steam does the work. The tube connecting the steam supply and the autoclave is provided with a pressure regulator, and as the autoclave is constantly fed automatically and a constant level preserved, the pressure remains constant at fifteen atmospheres. The products of the saponification, glycerin and fatty acids are continually delivered in a condition fit, the one for distillation, and the other for the press. S. P. S.

PHYSICS.

What are Brittle Bodies?—Under this head, Prof. Frederick Kick communicates the preliminary results of some very interesting experiments in *Dingl. Polytech. Journal*, **274**, 405. He starts with two theses: (1) Those bodies or substances are brittle which, in order to become ductile or plastic, must be subjected to a high pressure, acting uniformly from all directions. (2) The hardness of a substance may be determined with numerical accuracy by means of its shearing stress, if every bending and every fluxion of the material particles be excluded.

To substantiate the first thesis, the following experiments were made with pieces of gypsum, steatite, rocksalt and calcite, all of which are, under ordinary conditions, very brittle. The test materials were cut and ground into prismatic shape. A suitable piece of ordinary iron gas pipe was closed at one end with a well-fitting plug, and filled with molten shellac, avoiding carefully any formation of bubbles. Into this were immersed the test prisms which had previously been coated with shellac solution, and after filling up the remaining space with shellac, the top was closed by a second plug. The pipe was allowed to cool slowly for several hours, and then bent into **U**-shape. In dilute nitric acid, the iron pipe was dissolved, leaving the shellac core unaffected. This was dissolved in alcohol, leaving the bent prism of rocksalt, steatite, etc., in perfectly coherent shape. If a copper ring be soldered upon a piece of sheet tin, a prism of rocksalt placed within, and then the space filled with shellac, the pressure of a hydraulic ram will bring the rocksalt into the shape of a barrel.

With sulphur as a filling material, even better results are obtained than with shellac, but the best results gave stearic acid, a substance much softer than shellac, sulphur or rocksalt. From this it followed that the softer the enveloping material the better the results. The author constructed then a simple but effective apparatus, in which oil was the enveloping medium, and succeeded to alter the shape of the most brittle substances without affecting transparency or coherence.*

In regard to the second thesis, the author's experiments are few in number at time of publication, and whilst it seems true that the hardness and shearing stress are directly proportional, more experiments are necessary to establish the thesis as a law of nature. Shellac and tin are substances of widely differing nature and composition. Their hardness, however, is equal, and Prof. Kick finds for both the same shearing stress, *i. e.*, 2·6 kilograms to the square centimetre.

MISCELLANEOUS.

A COURT OF PATENT APPEALS.—At the stated meeting of the INSTITUTE, held December 18, 1889, the subject of the creation of a special tribunal for the determination of patent causes, which had been suggested by the President of the United States in a message to Congress, was debated at some length, and the desirability of some such provision was freely admitted.

There appears now to be a reasonable prospect that the action of the present Congress may provide a remedy for the serious defects of the present, and for sometime existing, judicial machinery for disposing of patent causes. As the matter now stands, inventors, and other litigants in such cases, are put to great expense, and obliged to suffer great injustice by reason partly of the length of time involved in the adjudication of patent cases in the United States Courts, because of the great amount of business of this character before

*These experiments recall Prof. Tyndall's observations on the plasticity of ice in the glaciers of the Alps made years ago. But then it was supposed that the melting and regelation were ample grounds upon which to explain the phenomenon.—*The Abstractor.*

these courts, and partly because of the faults of existing practice in respect of appeals to the United States Supreme Court, which will be spoken of hereafter. The burden thrown upon the court of last appeal has at length grown to such magnitude as to have become simply intolerable, and a reform is imperatively called for in justice both to the court and the litigants. The necessity for this reform was pointed out and strongly urged by the President in a recent message to Congress, wherein he embodied a recommendation for the establishment of an Intermediate Court of Appeals for the trial of patent cases; and, from present indications, the President's recommendation may have paved the way for this much-needed reform.

We notice, with considerable satisfaction, that the Judiciary Committee of the House of Representatives has reported favorably on a pending bill to establish a Court of Patent Appeals with three judges (the bill, as originally submitted, named five). In the committee's report there occurs the following statement of the benefits that may be expected to be realized from the establishment of such a court:

"(1) It would enable the public and patentees to determine the value and validity of patents without serious and vexatious delays, and thus promote the interests of all concerned.

"(2) It would relieve the Supreme Court of much of the burden imposed upon it by this class of litigation.

"(3) The practice in the Patent Court would become thoroughly fixed and understood, and, as a consequence, the issue of worthless patents, in which unscrupulous persons deal, to the injury of the public, would greatly be diminished, if not entirely suppressed.

"(4) It would tend to simplify the patent laws, by construction and settling questions of doubt, which are often used by litigants for the purpose of injustice and oppression."

Furthermore, the committee comments upon the duty imposed upon Congress of securing to authors and inventors, for a limited time, the exclusive right to their respective writings and discoveries, and states its belief, that, under the existing inadequate provision made by Congress to determine patent suits, by which it may happen that the life of a patent may expire before a decision is rendered, Congress is not properly discharging the duty imposed upon it by the constitution.

It is stated on good authority that it requires at present from two to three years to secure a decision in a patent suit from one of the United States Circuit Courts; and, in case of an appeal to the United States Supreme Court, a period of three or four more years will be required; which means, that if a patented invention is unfortunate enough to find its way into the courts—and this is the fate of the larger number of really valuable and profitable inventions—its owner will be compelled to sacrifice about one-fourth of its life in defending his rights.

One of the greatest faults of the existing practice, is that the Supreme Court passes judgment on questions of fact as well upon questions of law in patent suits; so that in important technical causes, it is no unusual sight to see the chambers of the court converted for the time into a mechanical, technical

or chemical workshop or museum. It seems utterly unnecessary to burden the highest court with the determination of questions of fact. These should be ascertained by the lower court, leaving for the court of last appeal simply the duty of defining the law in the cases brought before it. If this one defect were remedied, even under existing methods, it has been estimated that almost one-fourth of the time at present consumed in litigation over patents would be saved, to the advantage not only of this class of litigants, but also of others having business before the Supreme Court; to say nothing of the great relief it would afford to the overburdened members of the bench.

The legislation proposed by the House Committee will accomplish both of these desirable results. By the establishment of a special Court of Patent Appeals, it will entirely relieve the Supreme Court of the burden of adjudicating a class of causes that at present consume a large portion of its time to the detriment of other and most important interests, public and corporate. Furthermore, by the proposed new law, the judges of the lower courts, having passed on questions of fact and law, the duty of the judges of the appellate court will be confined simply to the review of the questions of law involved in causes carried up to them.

The passage of a law embodying substantially the features here indicated, would be of the utmost benefit to all who may be interested in the settlement of patent causes before the courts, while the public interests could be better served by the Supreme Court if relieved from a portion of its present heavy burden. It is a reform that should commend itself to Congressmen as entirely worthy of their support.

W.

BOOK NOTICES.

THE ENGINEER'S HOURLY LOG-BOOK. By Robert Grimshaw. New York: Practical Publishing Company.

If a log-book could be brought into general use among men having charge of steam plants, there would no doubt result a considerable saving in the expense of running, as, by its aid, a check could be placed on the various causes of waste, while, at the same time, the value of the fuel for steam purposes could be readily determined. In fact almost anything that will make men think will tend to produce a better quality of work, and while simply entering the various quantities in the log will not, of itself, increase the efficiency of the plant, a careful examination will be certain, in most cases, to point out the direction of improvement.

This particular log is not very well arranged, however. Mr. Grimshaw, as usual, tries to cover all cases, and the result is that the book is not very well adapted to any one.

Each page is divided horizontally into practically six divisions. In the first is put the date and hour. In the second, boiler pressure by gauge, fuel fired, pounds, ashes and unconsumed; in the next, combustible, pounds, uptake temperature, feed temperature; next, turns per minute and throttle

open; next, average cut-off, average vacuum inches, and hot-well temperature; and, in the last space, injection temperature, injection pounds, and indicated horse-power. Vertically, the page is divided for each hour, beginning at six and ending with five, thus putting twelve hours on each page. The apparatus required to fill out even this short log, is much more than is generally found about engine and boiler-rooms, but there is no question that it is desirable to have most of the data. The pounds of injection water has apparently been added to fill up the page, and the author dodges the method of filling this line of data, although full instructions are given for filling most of the rest of it. There is at the foot of each page a sort of a *résumé* of the work done, and here, perhaps, the most important of the items is omitted. The items are: Total hours run, kind of coal, cost coal per 2,240 pounds, oil, gallons, kind of oil, cost of oil per gallon; waste, pounds, steam, dry or wet, pounds water per pound, coal, per pound, combustible, per pound; coal from and at 212° per pound combustible from and at 212°. The *ordinary* method of determining the pounds of water per pound of coal, day in and day out, year in and year out, is not stated. If a meter is to be used, no provision is made for ever entering its readings.

Generally speaking, all data should be entered so that totals are the sums of columns of numbers and not of rows, as in this book. No place should be allowed in the log columns or rows for any data which can equally well be obtained for the totals. The pounds of combustible, average cut-off and indicated horse-power should have been put in the *résumé*. A book for general use as a log should on one page, or on two pages facing each other, give the hours from one to twelve or from six to six, in order that each full day's work may be entered on one page. Unless space is allowed for a running account of oil and waste, and probably for coal, the data are not of much value, as there is no check on the work from time to time.

H. W. S.

THE DEVELOPMENT OF THE PHILOSOPHY OF THE STEAM ENGINE. An historical sketch by Robert H. Thurston. New York: John Wiley & Sons. 1889. pp. vi, 48.

This work gives a clear idea of the steps leading up to the present condition of affairs in the theory of the steam engine, and states clearly and concisely the views entertained by the great theorists on the subject. The progress made in the actual economy of the engines at different stages in the growth of the theory is set forth, until, as the author states, at the present day the engineer has all the elements previously lacking of a valuable and satisfactory system of engine designing.

H. W. S.

ELEMENTARY LESSONS ON HEAT. By S. E. Tillman. Philadelphia: J. B. Lippincott Company. 1889. pp. 160.

This work was prepared by Professor Tillman to meet the wants of the Military Academy in this branch of physics. In the preface, the author states that in selecting the material he has been guided by the consideration

of what is applicable to the subsequent courses of study at the Academy, and also what is essential and most useful for a student to know. In the arrangement, he has kept in view facility of acquirement and thorough understanding, and, accordingly, the logical connection of the facts and principles set forth.

In the method of treatment the work is very clear, and much of the details of apparatus, which is entirely out of place in elementary work, is omitted, and there is no attempt made to cover all the theories that have existed pertaining to various branches of the subject.

The ground covered is exactly what is required for an elementary course, and the book would be a particularly useful one to students expecting later to take up the theory of heat engines. H. W. S.

GIFTS TO THE LIBRARY OF THE FRANKLIN INSTITUTE.

Agricultural Experiment Station. Alabama. Bulletin No. 8. From the Station.

American Academy of Arts and Sciences. Proceedings, Vol. 23, part 2. From the Academy.

American Institute of Mining Engineers. Seventeen Pamphlets Subject to Revision. From the Institute.

American Iron and Steel Association. Directory to the Iron and Steel Works, 1890. From the Association.

American Philosophical Society. Transactions. Vol. 16. Part 3. From the Society.

Andreen Fire-Proof Shutters and Doors. Descriptive Matter. From the Inventor.

Association pour Prévenir les Accidents de Fabrique. Compte-Rendu, Année 1888. Table Générale, 1867–1887. From the Association.

Backers Water Motor Company. Descriptive Pamphlet. From the Company.

Bliss Company, Brooklyn. Catalogue and Price List of Presses, Dies, etc. From the Company.

Boston Public Library. Bulletin No. 79. From the Librarian.

Brooklyn Library. Bulletin No. 27. From the Library.

Bryson, Andrew. The Return of Power in Electric and Cable Traction. From the Author.

Carolina Oil and Creosote Company. Descriptive Pamphlets. From the Secretary.

Carriage Monthly Daily, 1889. From Ware Brothers, Publishers.

Canada. Geological and Natural History Survey. Annual Report. 1887–88. From the Director.

Canadian Archives. Report by Douglas Brymer for 1889. From the Minister of Agriculture.

Canadian Institute. Annual Report. From the Institute.

Central Pacific Railroad Company. Relations between the Central Pacific Railroad Company and the United States Government. From the Southern Pacific Company.

Central Railroad Company of New Jersey. Annual Report. 1889. From the Company.

Chemical Society of Washington. Bulletin No. 4 and 5. From the Society.

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[*Proceedings of the Stated Meeting, held Wednesday, March 19, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, March 19, 1890.

JOSEPH M. WILSON, President, in the Chair.

Present, 106 members and eighteen visitors.

Additions to membership since last meeting, twenty-seven.

The Secretary presented the following communication from Mr. FRED'K FRALEY:

PHILADELPHIA, March 18, 1890.

Joseph M. Wilson, Esq., President FRANKLIN INSTITUTE.

MY DEAR SIR.—I hereby tender my resignation as Trustee of the ELLIOTT CRESSON MEDAL FUND of the FRANKLIN INSTITUTE, to take effect upon the appointment of my successor. Under the Trust Deed, the vacancy is to be filled by the INSTITUTE out of nominations made at one stated meeting, and voted on at the next or some subsequent stated meeting.

My years, and the desire to close all my Trust affairs during life, are my only reasons for my resignation, and I regret that my desire to be relieved was not fully understood when a successor to the late Mr. JOHN WIEGAND was chosen. I feel all my old interest in the INSTITUTE, and wish I were fifty years younger to labor for its welfare. Sincerely yours,

FRED K FRALEY.

The resignation of Mr. FRALEY was accepted, and Mr. GEO. V. CRESSON offered the following resolutions, which were unanimously adopted:

RESOLVED, That in regretfully accepting the resignation of Mr. FRED'K FRALEY as Trustee of the ELLIOTT CRESSON FUND, the FRANKLIN INSTITUTE desires to place on record its high appreciation of the able, conservative and faithful manner in which he has administered the trust.

RESOLVED, That the thanks of the INSTITUTE are due and are hereby tendered to Mr. FRALEY for his most efficient services.

Mr. SAMUEL SARTAIN was nominated as Trustee of the ELLIOTT CRESSON FUND, to fill the vacancy caused by Mr. FRALEY'S resignation. The nomination lies over for one month.

Mr. EASTON DEVONSHIRE, Assoc.M.Inst.C.E., late Resident Engineer and Manager of the Antwerp Water Works Company, Limited, read a paper

explaining the system and apparatus of Mr. W. ANDERSON for purifying water for the supply of cities and towns. The purifying material employed is iron, and the method involves the use of a revolving iron purifier of special construction, in connection with subsequent filtration through a filter-bed of sand. The speaker gave the results of an extended practical experience with the Anderson system at Antwerp, and illustrated the subject with the aid of diagrams, exhibiting the arrangement of the Anderson plant at Antwerp, and of lantern slides, showing the mechanical details of the purifier. The paper was discussed by Dr. GOLDSMITH, Messrs. U. C. SMITH, W. E. LOCKWOOD, the Secretary, and others, and has been referred for publication.

On Mr. LOCKWOOD'S motion, the thanks of the meeting were voted to Mr. DEVONSHIRE for his able and interesting paper.

Mr. WILLIAM VOLKMAR, of the Menlo Park Ceramic Works, gave a description of the improved processes employed at these works for the production of artistic faience and tiles, adapted for interior and exterior architectural adornment, illustrating his subject by the exhibition of a number of specimens of the company's products, which attracted much attention. (Referred for publication.)

The Secretary's Report embraced a description, with illustrations, of the recently-completed Forth Bridge, and the exhibition of several interesting views of the dynamite cruiser *Vesuvius*, one of which showed the position of the three pneumatic guns, with which the vessel is armed. These views were made from photographs, taken by Dr. W. O. GRIGGS, a member of the INSTITUTE.

Mr. S. LLOYD WIEGAND called attention to the great inconvenience to which inventors, attorneys and others requiring to make searches through the United States patent records are subjected, by reason of the want of suitable volumes containing abridgments of patents, such as are published by the British Patent Office, and which are of great advantage in saving time and labor that would otherwise be consumed in consulting numerous and bulky volumes of the complete specifications and drawings. He referred to the fact that the annual reports of successive Commissions of Patents had urged the expediency of publishing similar volumes of abridgments, suitably classified, of patents issued by the United States Patent Office; that the treasury of the United States held at the present time a sum of more than $1,000,000, derived from the profits accruing from the operations of the Patent Office, which sum was applicable solely to the improvement of this branch of the Government service. Also, the speaker called attention to the fact that at its stated meeting of April 18, 1888, the INSTITUTE had adopted a series of resolutions, embodying the facts above set forth, and he desired, in conclusion, that the INSTITUTE reaffirm its previous action above-named, and that the Secretary be instructed to forward to the Committee on Patents of the United States Senate and House of Representatives a copy of these resolutions. The resolutions were read by the Secretary, whereupon the motion of Mr. WIEGAND was adopted.

Adjourned.

WM. H. WAHL, *Secretary*.